

APPENDIX B - WET WEATHER FLOW MONITORING AND ANALYSIS

CITY OF MORGAN HILL
WET WEATHER FLOW
MONITORING & ANALYSIS
FINAL REPORT

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EXECUTIVE SUMMARY

V & A Consulting Engineers (V & A) was contracted by the City of Morgan Hill to perform a wet weather flow monitoring and analysis within the City of Morgan Hill. There were five distinct wet weather events during the test period. Flow meters were installed in nine manhole locations and data was collected from January 4, 2001 through April 17, 2001. The purpose of this analysis was to determine the magnitude of the rain-dependent infiltration and inflow (RDI/I) into the City's sanitary sewer system, pinpoint the problem areas within the City, and make recommendations as to the City's next course of action.

Flow metering and analysis of the results revealed the following:

- The most significant rain-dependent infiltration and inflow (RDI/I) contribution was from Site 13. Over the monitoring period, nearly 8 million gallons of water infiltrated the collection system upstream from this site. This site was the most responsive to wet weather events. The area downstream from the monitoring site was not captured during the flow monitoring. The potential exists for greater RDI/I contribution in the downtown area of Morgan Hill.
- Site 8 had nearly 3 million gallons of RDI/I contribution over baseline flow, and there is a good chance that the baseline flow determined for this site also includes a significant amount of groundwater. There was visible infiltration in the manhole during the initial meter installation.
- Sites 11 and 14 were responsive to wet weather events.

Due to the volume of infiltration contribution to RDI/I flow, it is recommended that the City of Morgan Hill proceed with smoke testing upstream from Basin 13 to look for possible inflow locations. Smoke testing of the downtown area downstream from the Site 13 monitoring location may also be considered. Properties within the greater downtown area should be investigated for downspouts from roofs which may be tied into the sanitary sewer system. Corrective measures should be taken. The Site 8 sewer line should be TV-inspected for infiltration. Inspection of corrective measures within Basin 14 following the smoke testing work should be checked for implementation. Additional public awareness recommendations are made in the *Recommendations* section of this report.

INTRODUCTION

V & A Consulting Engineers (V & A) was contracted by the City of Morgan Hill to install nine flow meters for three months in the City of Morgan Hill. Flow data was gathered in order to determine the magnitude of the rain-dependent infiltration and inflow (RDI/I) into the City's sanitary sewer system. After locations of excessive RDI/I are found, corrective measures can be implemented to mitigate the effects of the additional flow.

Flow monitoring data was collected from 9 monitoring locations targeting 9 coverage basins. These 9 basins covered approximately 40% to 45% of the entire collection system. During this period, there were 5 distinct wet weather events.

Figures 1 and 2 show the locations of the monitoring sites and the basin coverage areas.



Figure 1. Monitoring Sites Location Map

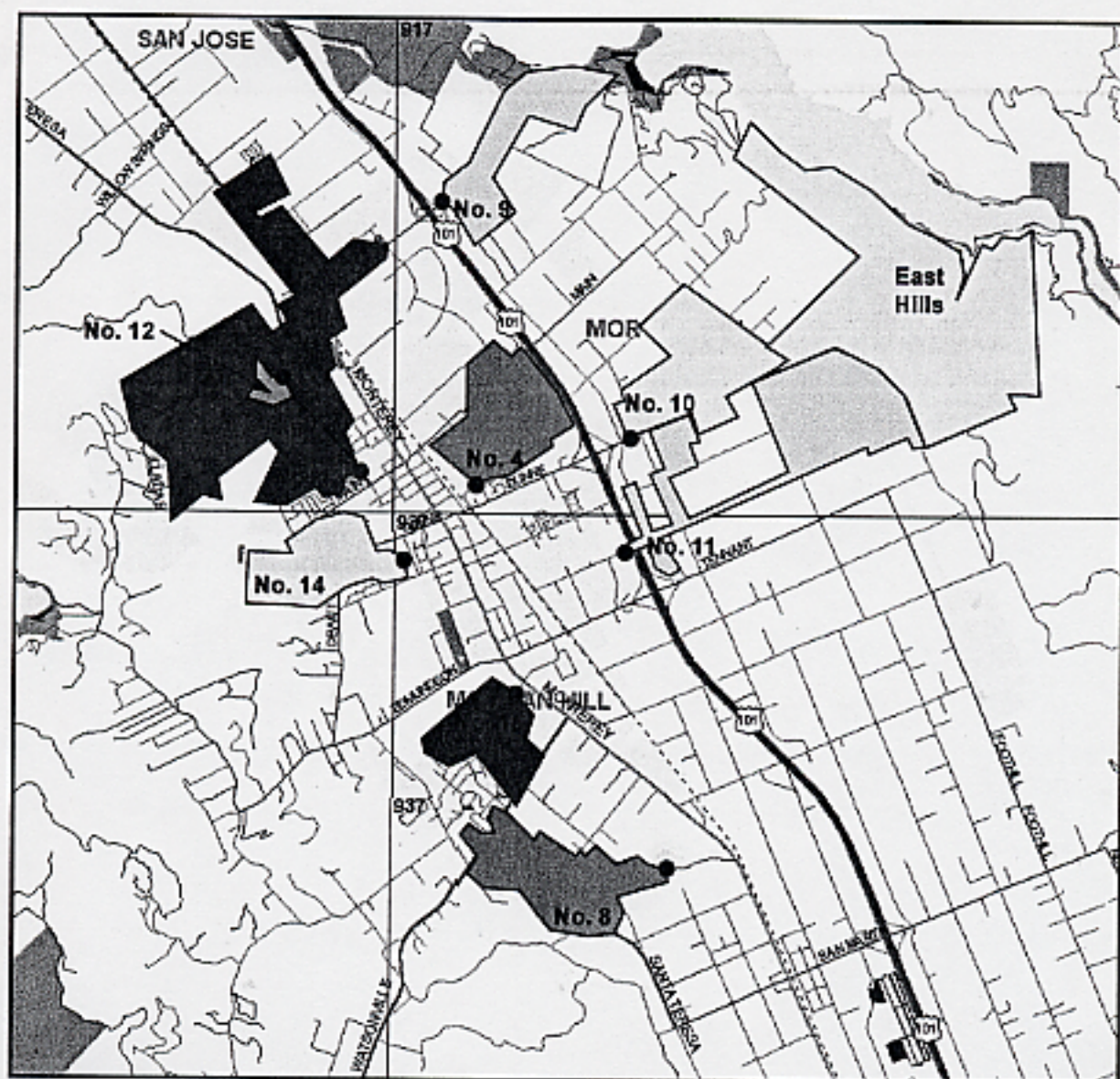


Figure 2. Basins Served by Flow Monitor Locations

DISCUSSION OF INFILTRATION AND INFLOW

Excessive RDI/I in a collection system can cause diluted wastewater flows to exceed sewer line capacities and therefore cause a backup in the system. Under extreme wet weather conditions, wastewater can potentially exit the system via manholes. Wastewater leaving a collection system in such a manner is called a sanitary sewer overflow (SSO). SSOs are unacceptable because they create a public health hazard and pollute the environment. The additional flow in the collection system due to the RDI/I also increases the volume and total cost of treating the wastewater at the treatment plant.

To reduce SSO's, typically an Infiltration/Inflow (I/I) correction program is implemented. The I/I correction program's overall purpose is to implement sewer improvements to effectively reduce I/I and manage wet weather wastewater flows. The following section further discusses general information regarding RDI/I.

There are many potential sources of I/I in a wastewater collection system. Infiltration sources are typically defects in deteriorated sewer pipes and include cracks, offset joints, root intrusion points, and broken pipes. Groundwater or rainwater in the vicinity typically enters the pipelines through these defects. Defects are generally more prevalent on older pipes. Sewers installed during the 1950's and before are more prone to leaks and deterioration than sewers installed after that time. In addition, sewer deterioration is accelerated due to the manufacturing, materials, and installation practices of that era. However, since the late 1950's, sewer pipe manufacturing processes and installation techniques improved significantly and there was a direct effect on the volume of infiltration into the sanitary sewers.

Infiltration is represented on flow data graphs by a gradual increase in flow after a wet weather event. The increased flow typically sustains for a short period after rainfall has stopped and then gradually drops off. Of course, there are many variables such as the level of ground saturation, the groundwater level, and the intensity and duration of the wet weather event. Therefore, many variations in flow graphs can be expected.

Compared to infiltration sources, **inflow** locations are relatively easy to find and usually less expensive to correct. These sources include direct and indirect cross connections with storm drainage systems, roof down spouts, and various types of surface drains. Although inflow sources are illegal in most areas, storm sewers and sanitary sewers can be unknowingly cross-connected. This is most prevalent where storm drains and sanitary sewers are placed in close proximity or cross over one another. Large magnitude, short duration spikes immediately following a rain event are indicative of inflow into the sanitary sewer.

METHODOLOGY

This section presents the general approach taken to analyze the flow monitoring data and to develop the design flow estimates used for the design storm analysis.

Having high quality wet weather flow data, dry weather flow data, and rainfall data is essential in defining the I/I contribution from individual drainage basins. Other useful data for this type of study includes groundwater levels in areas where the flow meters are installed. Once accurate data is obtained, careful review and analysis of the data in both tabular and graphical form is necessary.

Infiltration/Inflow Components

Infiltration/Inflow (I/I) components were developed to avoid misinterpretation of flow data. I/I components commonly used include groundwater infiltration (GWI), storm water inflow (SWI), and rainfall-dependent infiltration (RDI). The base wastewater flow (BWF) is the non-I/I component of the total flow. The I/I components are illustrated in Figure 3.

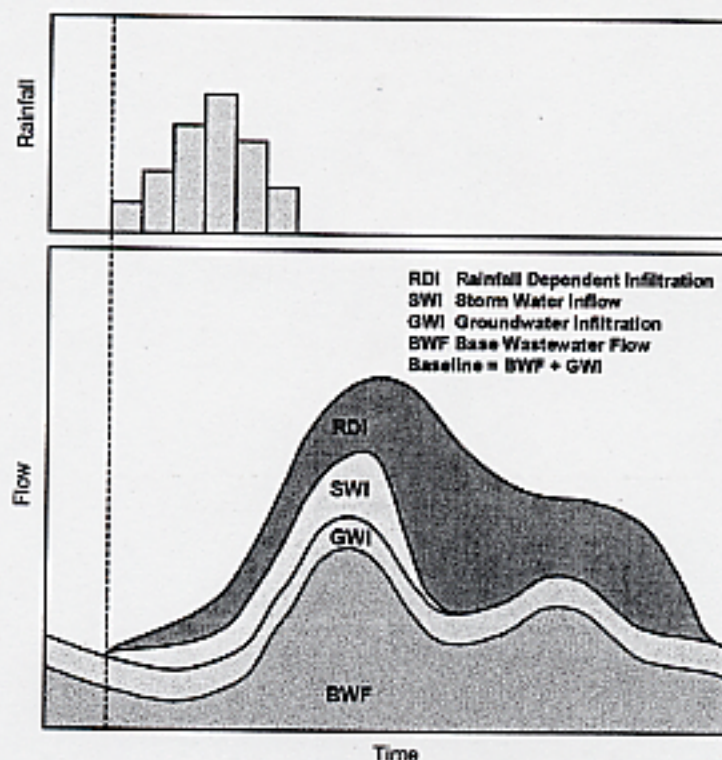


Figure 3. I/I Components

SWI and RDI are often represented together as rainfall-dependent infiltration/inflow (RDI/I)

because they are both directly influenced by the intensity and duration of a rainfall event and are often difficult to separate.

Groundwater Infiltration (GWI)

Groundwater infiltration is defined as groundwater entering the sanitary sewer system through defective pipes, pipe joints, and manhole walls. The magnitude of GWI depends on the depth of the groundwater table above the pipelines as well as the percentage of the system submerged. The variation in groundwater levels and subsequent GWI rates are seasonal in nature and usually greatest during the spring months due to the saturated groundwater levels succeeding the rainy season. For this study, it has been assumed that the groundwater table did not fluctuate greatly.

Baseline Flow

Baseline flow is defined as the flow that occurs through a pipeline during dry weather and normal usage conditions. Baseline flow was determined in this project by selecting days within the monitoring period when the RDI/I influence was negligible. It is not necessary to differentiate the GWI from the baseline flow because the objective of the analysis is to isolate the RDI/I component only.

Rainfall-Dependent Infiltration/Inflow (RDI/I)

Rainfall-dependent infiltration/inflow is defined as that portion of total I/I directly influenced by the intensity and duration of a storm event. This component will be the **main focus of this study**. RDI/I may further be subdivided into storm water inflow and rainfall-dependent infiltration.

Storm Water Inflow (SWI)

Storm water inflow is defined as water discharged into the sewer system, including private sewer laterals, from direct connections such as downspouts, yard and area drains, holes in manhole covers, cross connections from storm drains, or catch basins. This component of I/I creates a peak flow problem in the sewer system and, together with RDI, dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows.

Rainfall-Dependent Infiltration (RDI)

This component of I/I enters the sewer system through pipe defects similar to GWI and affects the system by contributing to peak flows as well as to the total I/I volume. The duration of a storm event, or successive storm events, has much influence over the volume of RDI contribution to RDI/I.

RDI/I Determination

The estimation of the RDI/I flows was the main emphasis in the analysis of flow monitoring data because RDI/I represents the greatest component of the peak wet weather flow in the sewer system. In order to estimate RDI/I, flow hydrographs for rainfall events were decomposed into their baseline flow and RDI/I components. Five wet weather events were analyzed for each site, of which one event was chosen as the primary event used for the RDI/I analysis. The steps in this process are summarized in the following paragraph.

Baseline flows were plotted against the total flow for the storm event being analyzed. During this process, the early morning baseline flows were compared to the early morning flows immediately preceding the storm event. Differences in minimum flows may have occurred due to changes in GWI, or it is possible that there was some residual RDI/I from a previous storm. In the event of a previous storm overlapping a current storm, appropriate recession slopes were determined for more precise calculations. Taking this possible interference into account, the baseline flow was subtracted from the total flow to determine the RDI/I flow for the wet weather event. A typical decomposed hydrograph and resultant RDI/I hydrograph are shown in Figure 4.

Finally, the total volume of the storm RDI/I hydrograph was calculated and expressed in terms of R, the ratio of total RDI/I volume to total precipitation volume for the storm. The precipitation volume was computed by multiplying the rainfall amount by the basin coverage area.

It should be understood that conclusions about RDI/I flow are somewhat subjective and depend on many assumptions about the numerous variables involved in flow monitoring and their interactions on each other. These variables include, but are not limited to, configuration of the collection system infrastructure, piping hydraulics, topography, soil type, pipeline age, rainfall patterns and groundwater depth. The general philosophy in reducing and interpreting I/I flow data is to concentrate on the **relative** changes during times of wet weather events, more so than the "absolute" changes relative to the baseline data. Flow can be very dynamic based on the time of year (holiday, festival, variable population changes, etc.) and many other factors. Being flexible and allowing for flow variation in the interpretation of data allows us to compare the various sites with a greater degree of confidence.

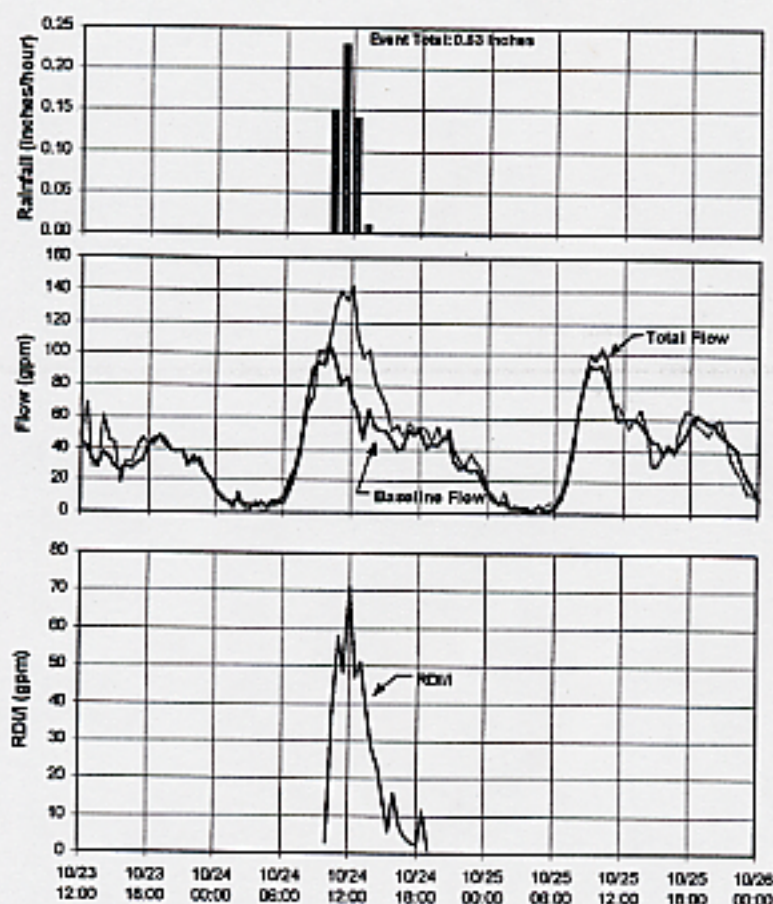


Figure 4. Typical Decomposed Hydrograph

Ultimately, from the RDI/I estimates and design storm estimates, recommendations are made for reducing both infiltration and inflow. For each basin, the recommendations may differ depending on the individual characteristics of that drainage basin, differences in flows, and economics. As always, RDI/I reduction should balance the costs of reducing or eliminating RDI/I with the costs for storage, transport, and treatment of the additional flows contributed by RDI/I.

FIELD MONITORING PROCEDURE

On January 4, 2001, V & A Consulting Engineers installed Sigma 910 Flowmeters at nine locations throughout the City of Morgan Hill (See Figure 1). Sigma meters use a pressure transducer to collect depth readings, and ultrasonic Doppler sensors on the probe determine the average fluid velocity. The meters are installed such that the level/velocity sensor is facing into the flow. A typical installation of this type of meter is shown in Figure 5.

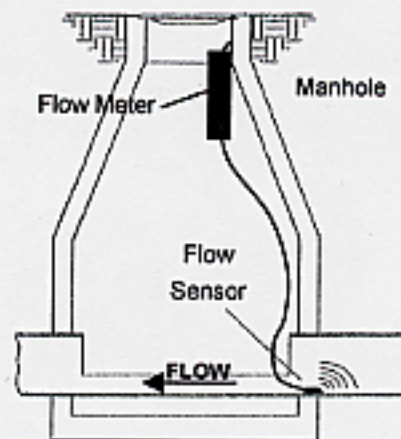


Figure 5. Flow Meter Installation Set-Up

Manual level and velocity readings were taken in the field during the flow meter installation and removal for comparison to the readings of the flow meter to ensure proper calibration and accuracy. Data was collected from January 4, 2001 through April 17, 2001. The continuous depth and velocity readings were recorded by the flow meter in 15-minute increments and transferred into a computer spreadsheet program where the data could be analyzed and made report ready.

RESULTS

Rainfall Data

Two Sigma Rain Metering Gauges were installed in this study. One meter was installed on the pavement of an open space within the confines of the East Dunne Pump Station, and one meter was installed on the roof of the Cochrane Pump Station. Both sites had very similar data. The Cochrane Pump Station site had a greater degree of open air space and this data was used for this study, and is summarized in Figure 6.

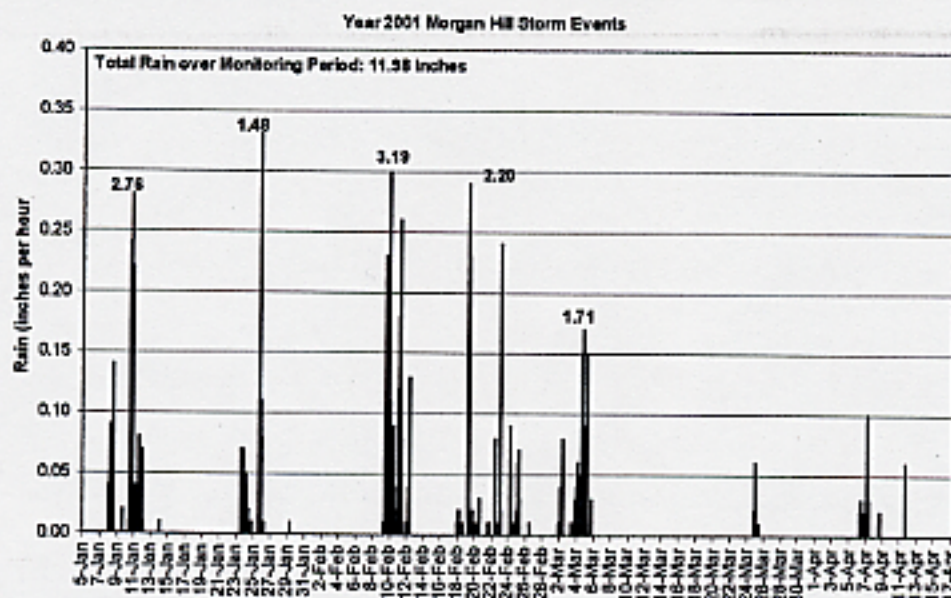


Figure 6. Rainfall over Monitoring Period

This data can be grouped into 5 major rainfall events. These 5 events encompass 95% of the total rainfall recorded over the monitoring period. Minor rainfalls were not included as an event. Table 3 further describes the rainfall events.

Table 1. Events over Monitoring Period

Event Number	Event Start Date	Event Total (in)	Event Length (hrs)	Max. Rate (in/hr)	Avg. Rate (in/hr)	Description
1	01/08/01 01:00	2.76	96	0.28	0.03	1 half day light rainfall, followed by 1 ½ days of moderate rain.
2	01/23/01 13:00	1.48	58	0.33	0.03	1 day light event, followed by a ½ day spike.
3	02/09/01 06:00	3.19	76	0.30	0.04	3 ½ days of solid, moderate rain.
4	02/17/01 22:00	2.20	178	0.29	0.01	1 week of sporadic, light rainfall, with two short-lived spikes
5	03/01/01 22:00	1.74	81	0.17	0.02	½ day of light rainfall, followed by 1 ½ days of moderate rain

The rainfall for this study can be considered average. Also, most of the wet weather season was encompassed with monitoring starting before significant rains events fell, and ending significantly after the final rain events.

Flow Monitoring Data

Complete graphs of the level, velocity and flow data in 15-minute intervals are found in *Appendix C* and are categorized by site. The results of the flow monitoring data are summarized in Table 4.

Table 2. Summary of Flow Monitoring Data

Site	Baseline Flow (MGD)	Peak Realtime Flow (MGD)	Total Baseline Flow (Mgal)	Total Realtime Flow (Mgal)	Total RDI/I Flow (Mgal)
4	0.174	0.459	17.77	16.45	-1.32
8	0.170	0.485	17.45	20.31	2.86
9	0.006	0.047	0.63	0.66	0.03
10	0.111	0.370	11.44	11.22	-0.22
11	0.446	1.037	45.86	47.17	1.31
12	0.010	0.047	1.05	1.12	0.07
13	0.356	1.256	36.76	44.54	7.78
14	0.168	0.551	17.05	18.81	1.76
15	0.054	0.276	5.36	6.17	0.82

Baseline flow was determined in this project by selecting days within the monitoring period when the RDI/I influence was negligible. The baseline flow days selected were as follows:

- **Weekdays:** January 5, January 16, January 17, January 18, January 19, January 22, January 30, January 31, February 1, February 2, February 5, February 6, February 7, February 8.
- **Weekends:** January 6, January 7, January 20, January 21, February 3, February 4

Each data point could be averaged to determine the expected baseline flow for each site in 15-minute intervals. These are the baseline flows in which RDI/I flow is based. Figure 7 shows a sample baseline flow graph. The baseline flow graphs for each site are found in *Appendix A*.

The baseline flow was determined for comparison the realtime (actual) data. Increases during wet weather events can be clearly seen and the difference between the baseline and realtime data represents the RDI/I flow. Figure 8 shows a sample Baseline vs. Realtime graph. This graph also includes the RDI/I flow and rainfall data. The complete set of Baseline vs. Realtime Graphs for each site is found in *Appendix C*.

Peak realtime flow is the peak flow recorded over the course of the monitoring period. A high peak realtime flow may indicate inflow.

The total baseline flow is the *projected* total flow through the pipeline at the monitoring site for continuous baseline conditions over the monitoring period. The total realtime flow is the actual total flow recorded at the monitoring site over the monitoring period. The total RDI/I flow is the difference between the projected baseline flow and the realtime flow. This number emphasizes the total volume infiltration and inflow that passes through to the treatment plant. Of the sites monitored, Site 13 clearly has the greatest volume of RDI/I flow entering the collection system. The negative total RDI/I in Site 10 may be due to slight calibration/meter error. It is unknown why Site 4 flow seemed to decline in flow after Week 13.

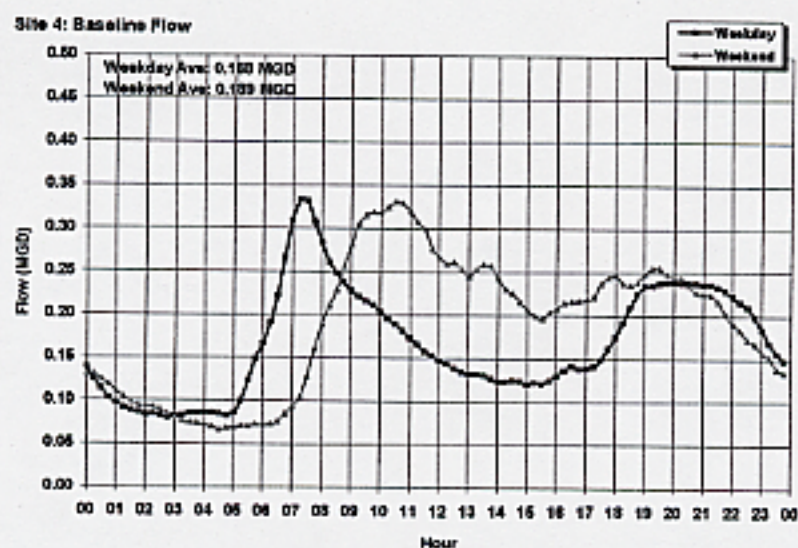


Figure 7. Sample Baseline Flow Graph, Site 4

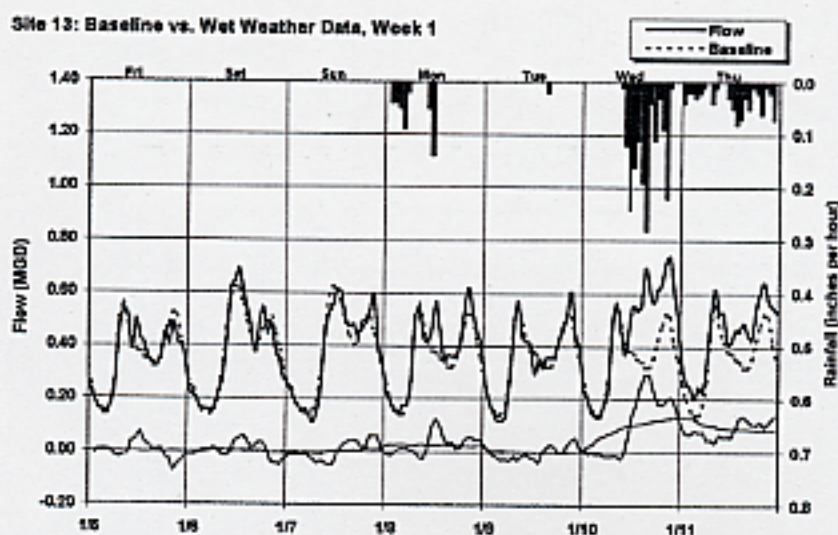


Figure 8. Sample Baseline vs. Wet Weather Flow Graph, Site 13, Week 1

RAIN-DEPENDENT INFLOW/INFILTRATION ESTIMATES

During the 15-week period, there were 5 distinct wet weather events. Monitoring Sites 4, 9, 10, 12, and 15 did not show definitive flow increases that could be directly attributed to any of the wet weather events. Monitoring Sites 8, 11, 13 and 14 did show an increase in flow during the wet weather events. Figure 9 shows a sample of an RDI/I hydrograph used to determine the volume of RDI/I flow for a particular rainfall event. The hydrographs for all of the analyzed sites and events are found in *Appendix B*.

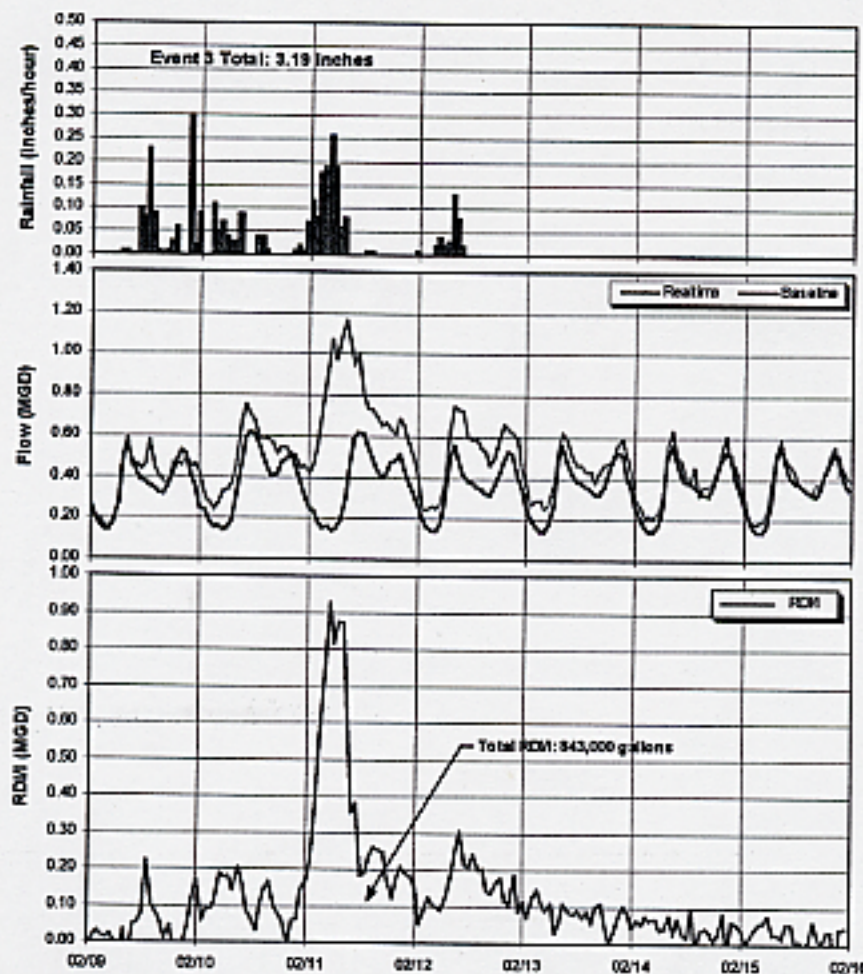


Figure 9. Sample Hydrograph, Site 13, Event 3

Table 5 summarizes the RDI/I results for the monitoring sites for each of the wet weather events. Event 4 was not analyzed due to its long duration and low intensity.

Table 3. Summary of RDI/I Results

	Site 8	Site 11	Site 13	Site 14
Event 1				
RDI/I Volume in Basin (gal x 1,000)	44.0	145.0	267.0	77.0
Rainfall Volume in Basin (gal x 1,000)	22,142	15,863	42,301	11,567
R-Value	0.2%	0.9%	0.6%	0.7%
Event 2				
RDI/I Volume in Basin (gal x 1,000)	-	-	93.0	73.0
Rainfall Volume in Basin (gal x 1,000)	11,873	8,506	22,683	6,202
R-Value	-	-	0.4%	1.2%
Event 3				
RDI/I Volume in Basin (gal x 1,000)	267.0	71.0	843.0	278.0
Rainfall Volume in Basin (gal x 1,000)	25,592	18,334	48,891	13,369
R-Value	1.0%	0.4%	1.7%	2.1%
Event 5				
RDI/I Volume in Basin (gal x 1,000)	119.0	292.0	628.0	169.0
Rainfall Volume in Basin (gal x 1,000)	13,959	10,001	26,668	7,292
R-Value	0.9%	2.9%	2.4%	2.3%

A " - " indicates that RDI/I flow could not be definitely determined

Though Event 4 was not analyzed, the importance of Event 4 should not be overlooked. Because of Event 4, the soils were heavily saturated for Event 5, which, as shown for every site above, caused the greatest R-Values of the monitoring period. Figure 10 compares the maximum R-Values per site.

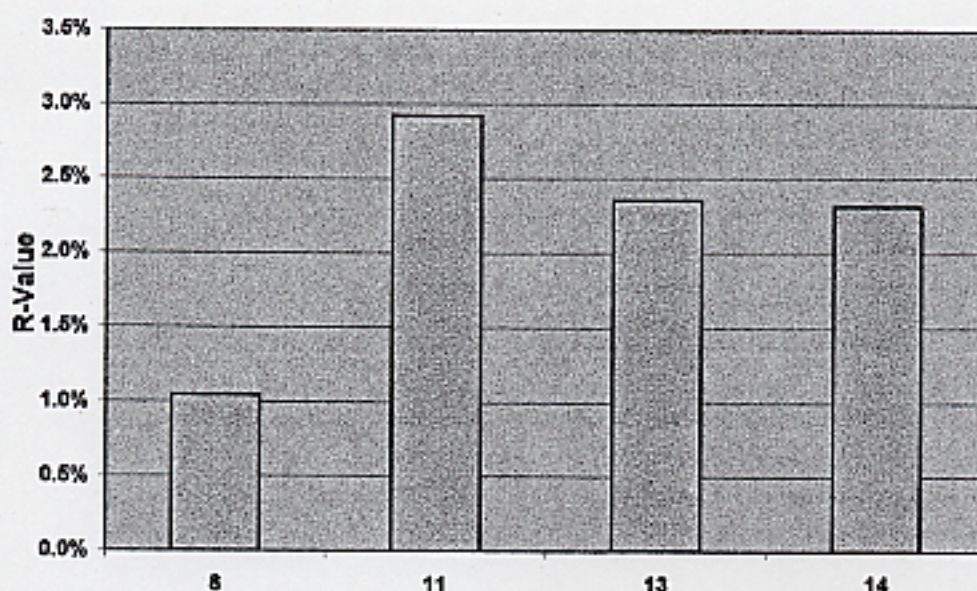


Figure 10. Max R-Values by Site

The peak RDI/I flow was determined and compared to the average baseline flow as a percentage to get an indication of the magnitude of Storm Water Inflow (SWI) within a particular basin. Table 4 summarizes the peak RDI/I results and Figure 11 shows those results graphically.

Table 4. Peak RDI/I Summary

	Site 8	Site 11	Site 13	Site 14
Baseline Flow (MGD)	0.170	0.446	0.356	0.168
Peak RDI/I (MGD)	0.139	0.398	0.930	0.262
Ratio of Peak RDI/I to Baseline Flow	82%	89%	261%	156%

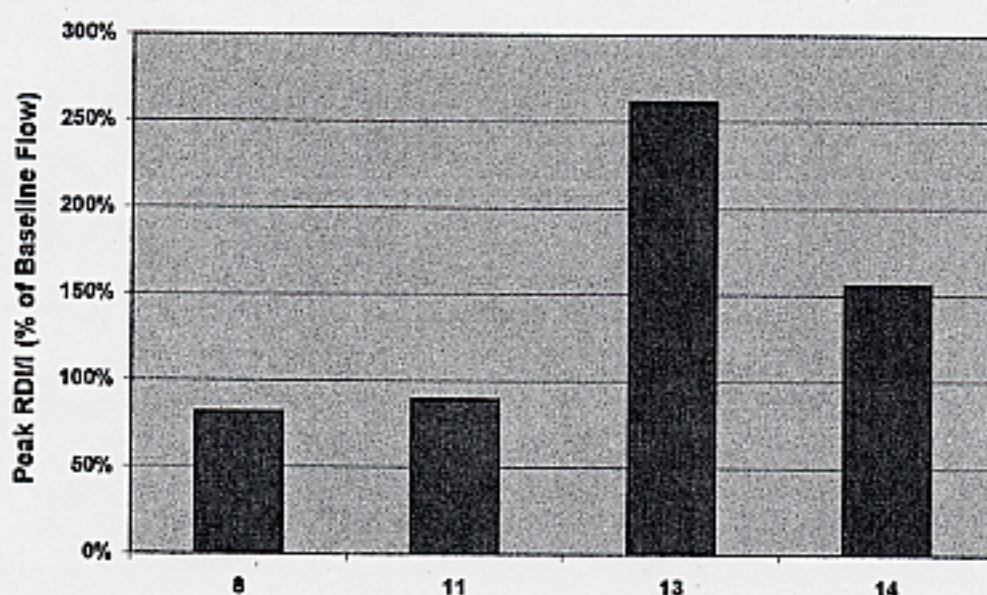
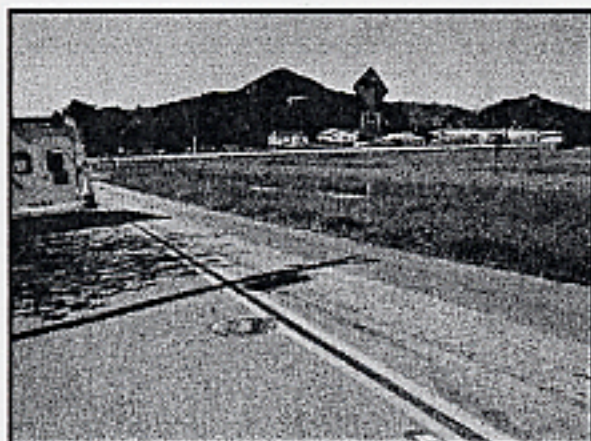
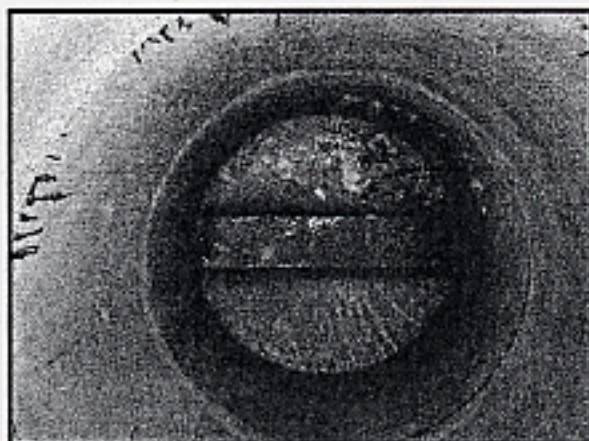


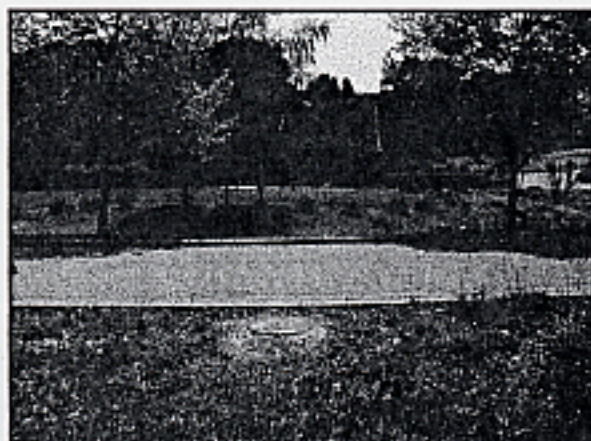
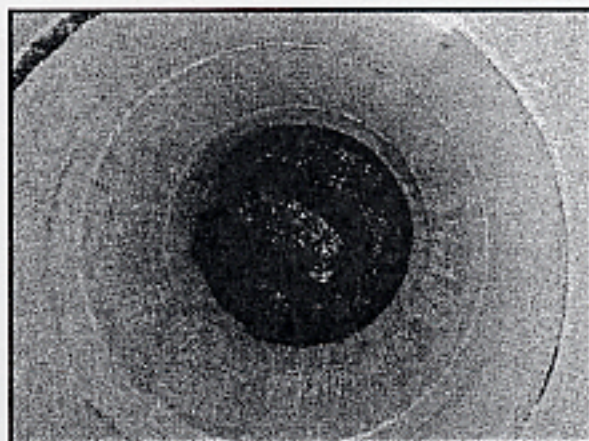
Figure 11. Peak RDI/I Flows by Site

General comments: The year of rainfall over the monitoring period can be considered an average year. Flow monitoring generally encompassed the start and end of the rainy season, thus for most sites, the total RDI/I flow can be considered an average volume of infiltration for an average rainy season. Site 13 deserves the most attention, as its total volume of RDI/I was significantly greater than any other site. The trunk line for Site 13 runs parallel to a riverbed, where it may be speculated that there is a high groundwater level.

The Site 8 line runs parallel to a river as well. Upon initial flow meter installation at this site, infiltration at the lower barrel joints in the manhole was evident. This line may be below the groundwater level for all seasons of the year. There is a good chance that the baseline flow determined for this site also includes a significant amount of groundwater.

SITE-BY-SITE ANALYSIS**Site No. 4****Photo 1. Site 4 View from Above****Photo 2. Site 4 Plan View**

Site No. 4 is a 10-inch PVC pipe at Diana Avenue, north of Butterfield Road. This site did **not** show definitive flow increases that could be directly attributed to any of the wet weather events. There are no significant RDI/I problems here.

Site No. 8**Photo 3. Site 8 View from Above****Photo 4. Site 8 Plan View**

Site No. 8 is a 12-inch PVC pipe located in an easement off Atherton Circle. This did have a

response to wet weather events, and had the second greatest volume of RDI/I flow at 2.86 million gallons over the course of the monitoring period. The Site 8 line runs parallel to a river. Upon initial flow meter installation at this site, infiltration at the lower barrel joints in the manhole was evident. This line may be below the groundwater level for all seasons of the year. There is a good chance that the baseline flow determined for this site also includes a significant amount of groundwater. Looking at the weekly Baseline vs. Realtime graphs (*Appendix C*), the RDI/I curve was very smooth with few spikes. Also, the flow took an extended period of time to return to baseline levels. This indicates that the RDI/I upstream from this location is mostly infiltration with very little, if any, inflow. Increases in flow will correspond with increases in the groundwater level.

Site No. 9

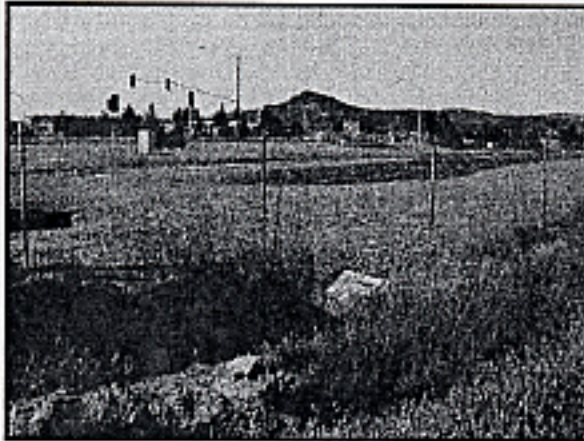


Photo 5. Site 9 View from Above

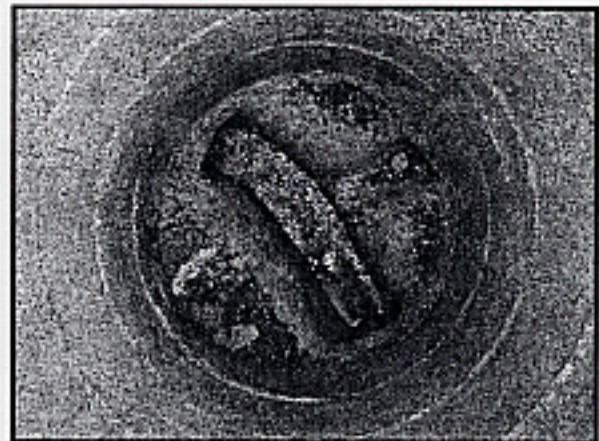
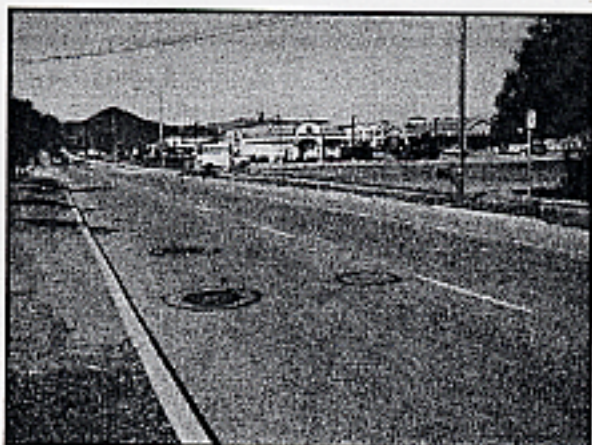
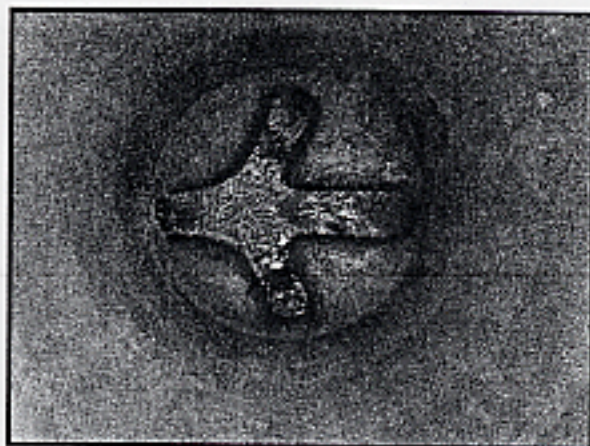
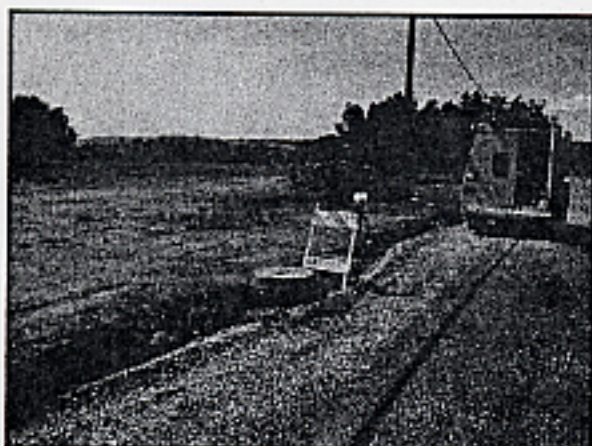
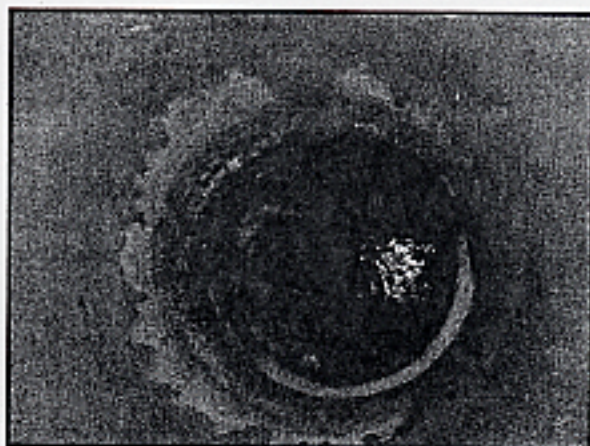


Photo 6. Site 9 Plan View

Site No. 9 is a 12-inch vitrified clay pipe in an easement off Cochrane Road near Highway 101. This basin had a relatively low flow volume did not show definitive flow increases that could be directly attributed to any of the wet weather events. There are no significant RDI/I problems here.

Site No. 10**Photo 7. Site 10 View from Above****Photo 8. Site 10 Plan View**

Site No. 10 is an 8-inch vitrified clay pipe on East Dunne Avenue West of Murphy Avenue. The flows at this site also include flows from the east hills area near the Androon Reservoir. There is a manhole upstream from Site 10, where there is located an overflow line during times of excessively high flow. Overflows would then have been monitored at Site 11. This site did **not** show definitive flow increases that could be directly attributed to any of the wet weather events. Overall, there are no significant RDI/I problems here.

Site No. 11**Photo 9. Site 11 View from Above****Photo 10. Site 11 Plan View**

Site No. 11 is a 12-inch PVC pipe located in an easement off Barrett Avenue. This site would monitor the lower east hills area, but additionally, during times of high flow, may also monitor

the upper east hills area due to an overflow line located on East Dunne and Hill Road. Note that the upper east hills basin area was not included in this basin area for these calculations. This site did have a response to wet weather events, and had the fourth greatest volume of RDI/I flow at 1.31 million gallons over the course of the monitoring period. The quick recession times of the RDI/I flow, in combination with the small instantaneous peaks, indicate the presence of both rain-dependent infiltration (RDI) and storm water inflow (SWI).

Site No. 12

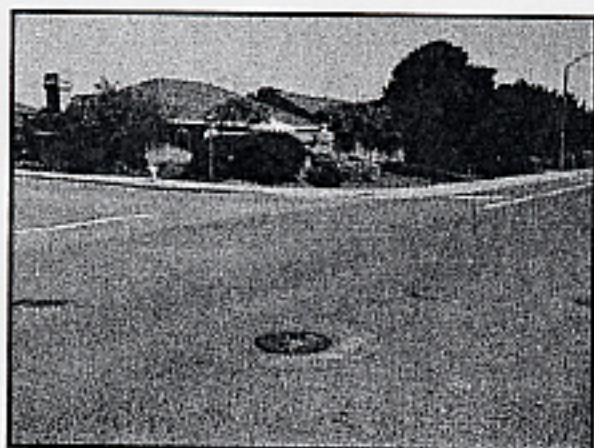


Photo 11. Site 12 View from Above

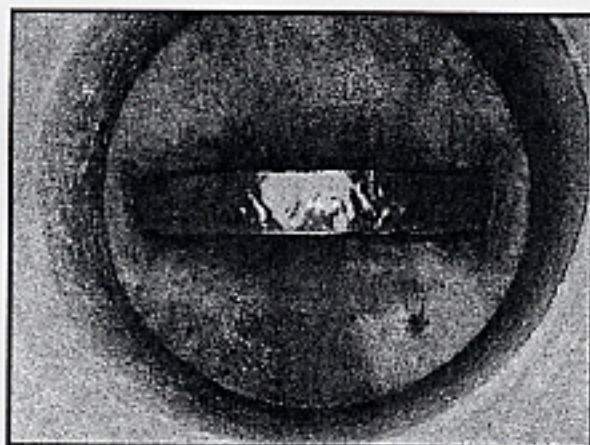
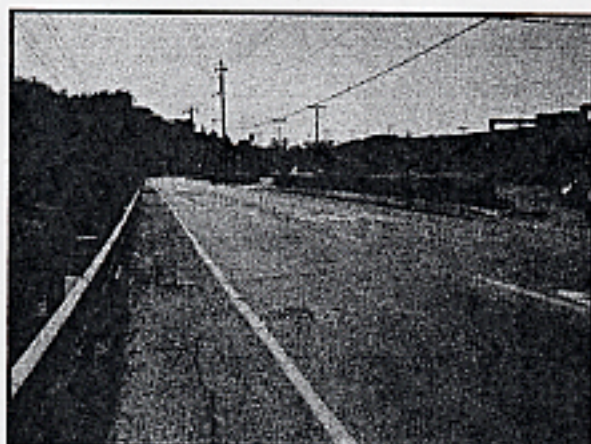
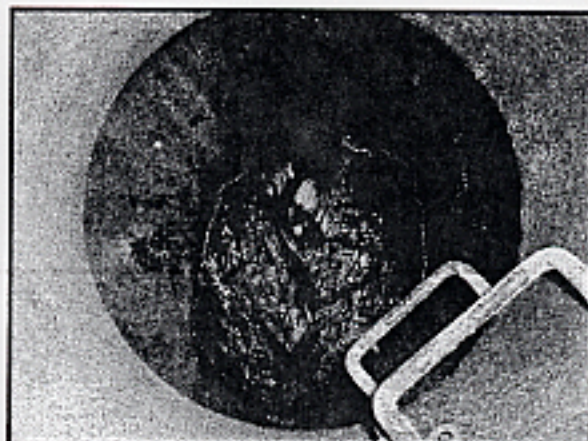
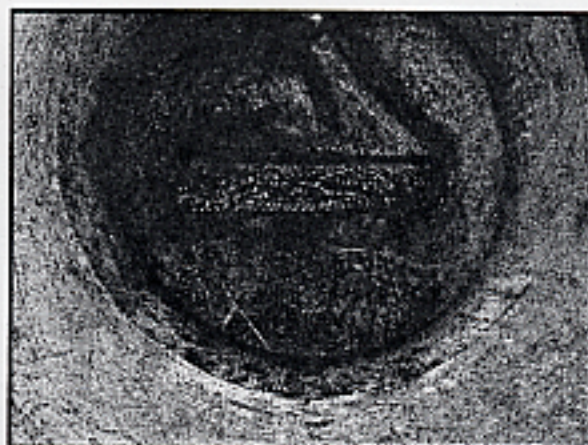


Photo 12. Site 12 Plan View

Site No. 12 is an 8-inch vitrified clay pipe at the intersection of Llagas Road and Murphy Spring Drive. The basin coverage area of this site is relatively small. This basin had a relatively low flow volume did **not** show definitive flow increases that could be directly attributed to any of the wet weather events. There are no significant RDI/I problems here.

Site No. 13**Photo 13. Site 13 View from Above****Photo 14. Site 13 Plan View**

Site No. 13 is a 15-inch vitrified clay pipe on Hale Road north of Main Avenue. The basin of this site engulfs the basin coverage area of Site 12. This site deserves the most attention, as its total volume of RDI/I was significantly greater than any other site at 7.78 million gallons over the course of the monitoring period. The trunk line for Site 13 runs parallel to a riverbed, where it may be speculated that there is a high groundwater level. Of all of the sites, this site had the greatest response to rainfall events. The RDI/I flow had both immediate peaks as well as long recession times, indicating the presence of both rain-dependent infiltration (RDI) and storm water inflow (SWI).

Site No. 14**Photo 15. Site 14 View from Above****Photo 16. Site 14 Plan View**

Site No. 14 is an 8-inch concrete pipe in an easement of Barnell Avenue. Site 14 neighbors Sites 12 and 13. This site did have a response to wet weather events, and had the third greatest volume of RDI/I flow at 1.76 million gallons over the course of the monitoring period. The RDI/I flow generally had quick recession times, indicating a greater presence storm water inflow (SWI). The R-values determined at this site were moderately high.

Site No. 15

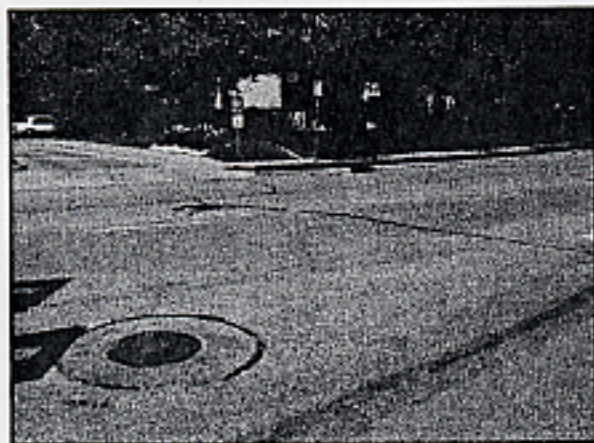


Photo 17. Site 15 View from Above

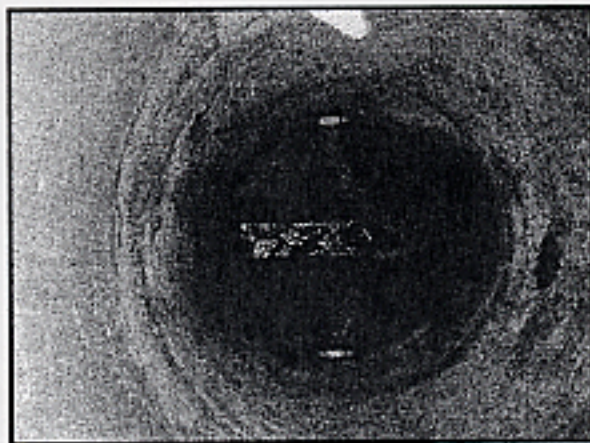


Photo 18. Site 15 Plan View

Site No. 15 is a 10-inch PVC pipe located on Vineyard Boulevard. This basin had a relatively low flow volume did not show definitive flow increases that could be directly attributed to any of the wet weather events. There are no significant RDI/I problems here.

CONCLUSIONS

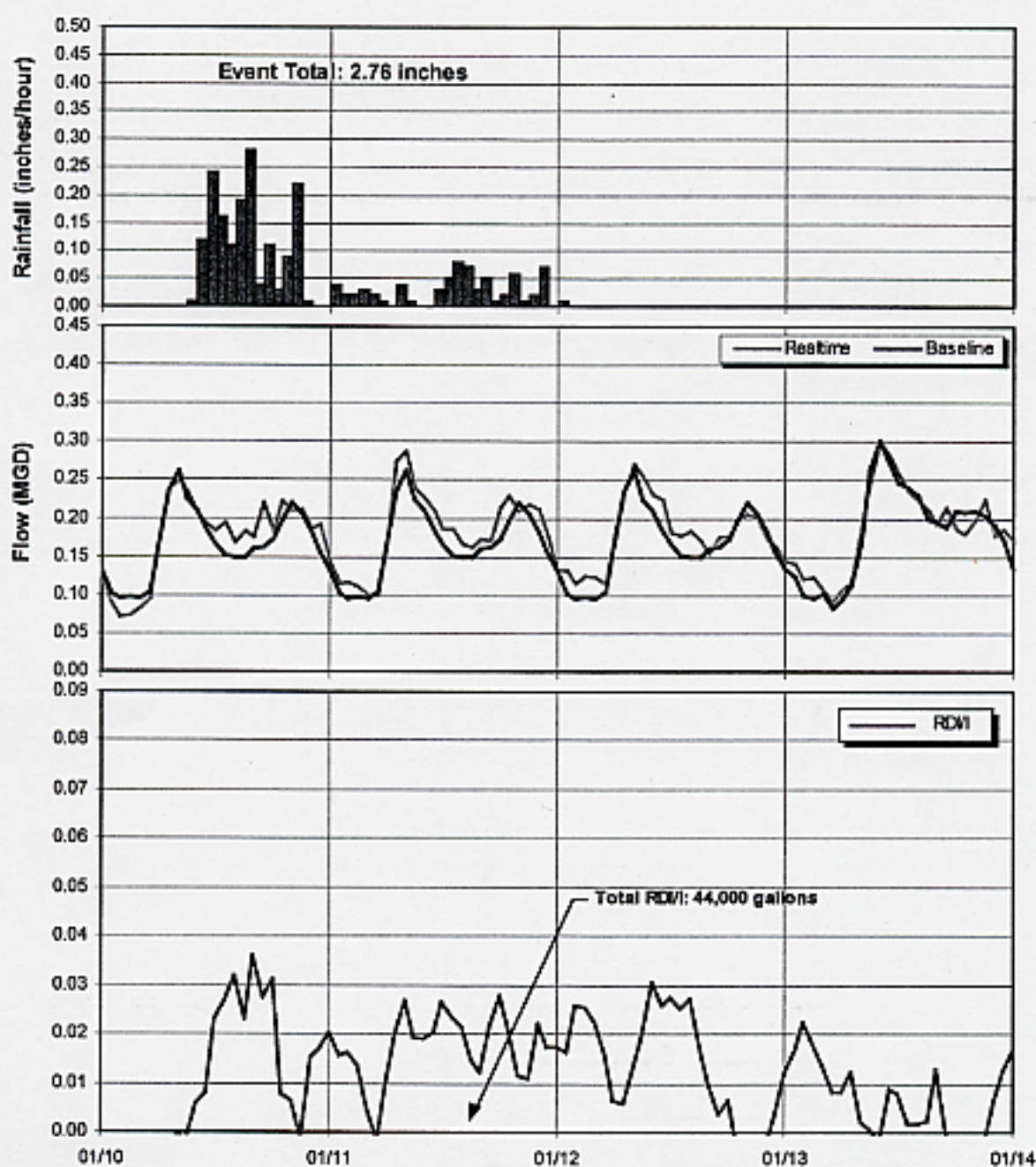
- The most significant RDI/I contribution was from Site 13. Over the monitoring period, nearly 8 million gallons of water infiltrated the collection system upstream from this site. This site was the most responsive to wet weather events. The area downstream from the monitoring site was not captured during the flow monitoring. The potential exists for greater RDI/I contribution in the downtown area of Morgan Hill.
- Site 8 had nearly 3 million gallons of RDI/I contribution over baseline flow, and there is a good chance that the baseline flow determined for this site also includes a significant amount of groundwater. There was visible infiltration in the manhole during the initial meter installation.
- Sites 11 and 14 were responsive to wet weather events.
- Generally, the areas tested had relatively low volumes of rain-dependent infiltration into the collection system. Based on the flow data and depth of flow in the sewers, the City is not in immediate danger of SSO's due to excessive inflow and infiltration.

Conclusions presented are based on the data gathered during this study. Additional flow data collection could result in different findings due to changing condition of the sewer system, and the intensity of the rainfall events monitored.

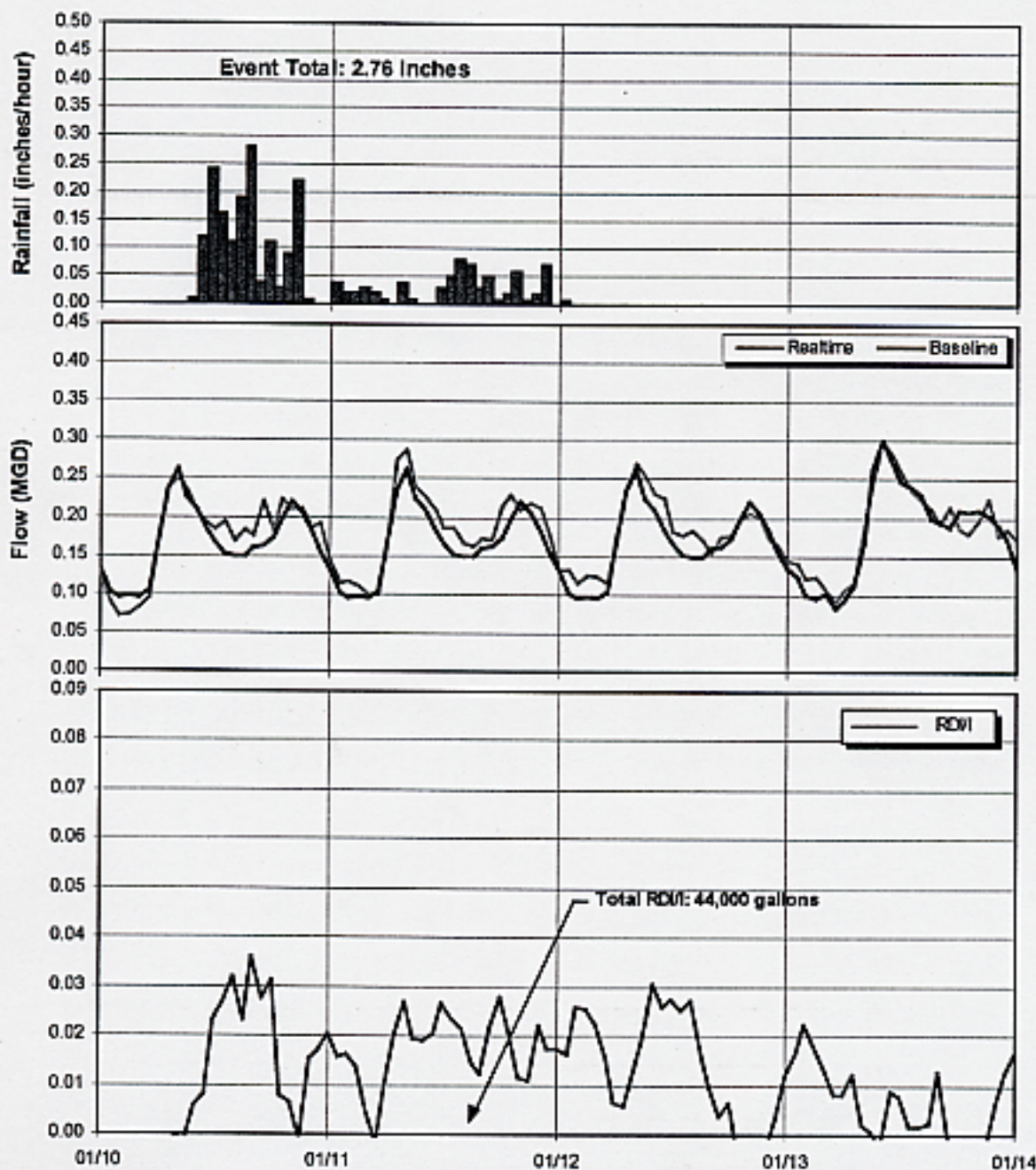
RECOMMENDATIONS

The following recommendations are based on our understanding of the City's needs and obligations, the capacity of the treatment plant, and review of the flow monitoring data. These recommendations do not consider the financial constraints of the City.

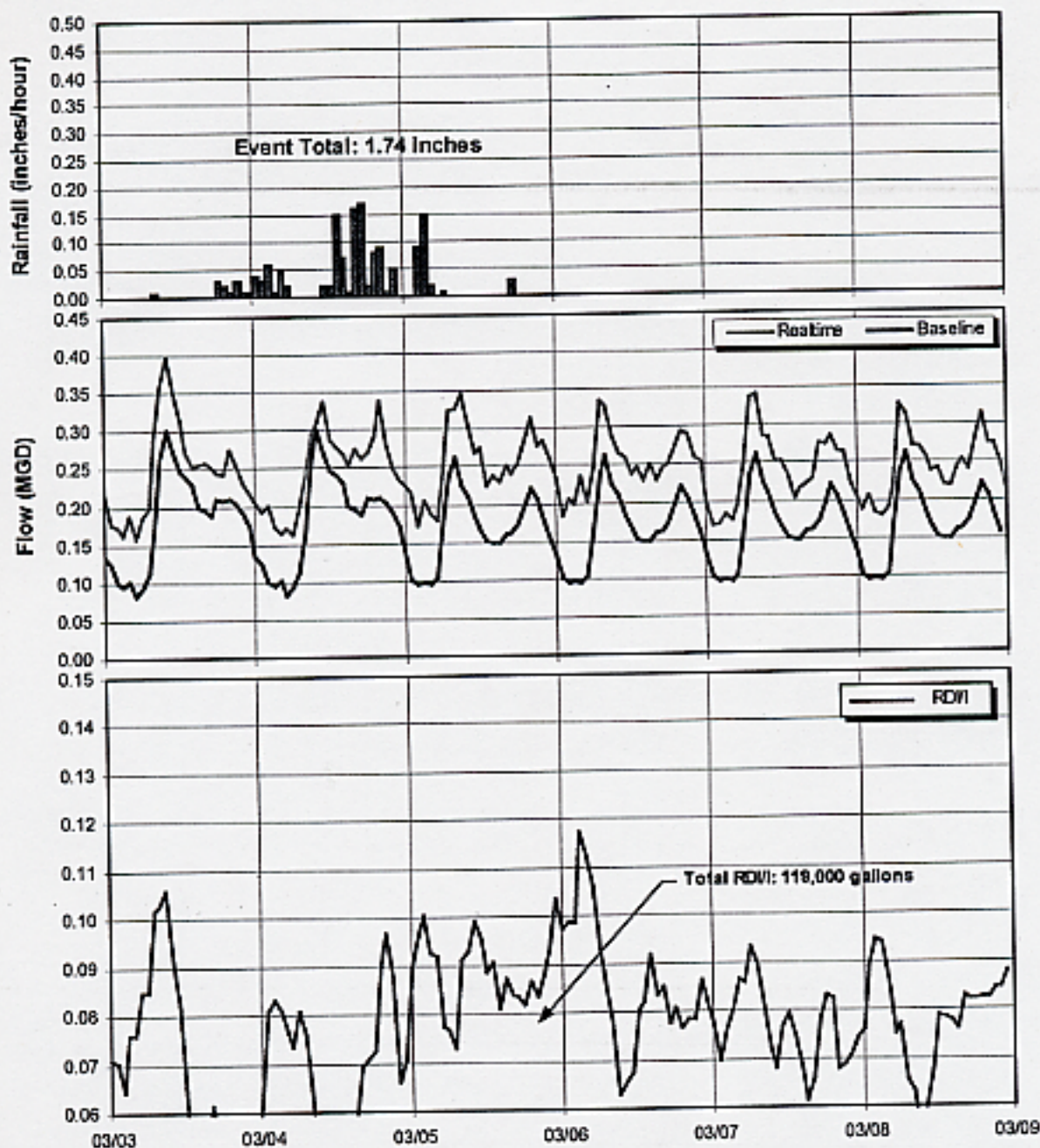
- Due to the volume of infiltration contribution to RDI/I flow, it is recommended that the City of Morgan Hill proceed with smoke testing upstream from Basin 13 to look for possible inflow locations.
- Smoke testing of the downtown area downstream from the Site 13 monitoring location may also be considered. Properties within the greater downtown area should be investigated for downspouts from roofs which may be connected to the sanitary sewer system. Corrective measures should be taken.
- The Site 8 sewer line should be TV-inspected for infiltration.
- Inspection of corrective measures within Basin 14 following the smoke testing work should be checked for implementation.
- Update and enforce the City sewer ordinances as required to implement the program recommendations, including an ordinance requiring testing and repair of the privately owned portion of sewer laterals as a condition on the sale of property.
- Initiate a comprehensive, ongoing public information program focused on project implementation.
- Institute a program of periodic flow monitoring and sewer system testing and inspection to determine the effectiveness of rehabilitation and to avert the development of excessive RDI/I in the future.
- Based on the flow monitoring and the additional testing, a plan that efficiently and effectively meets the City's needs to reduce the adverse effects of I/I should be devised.



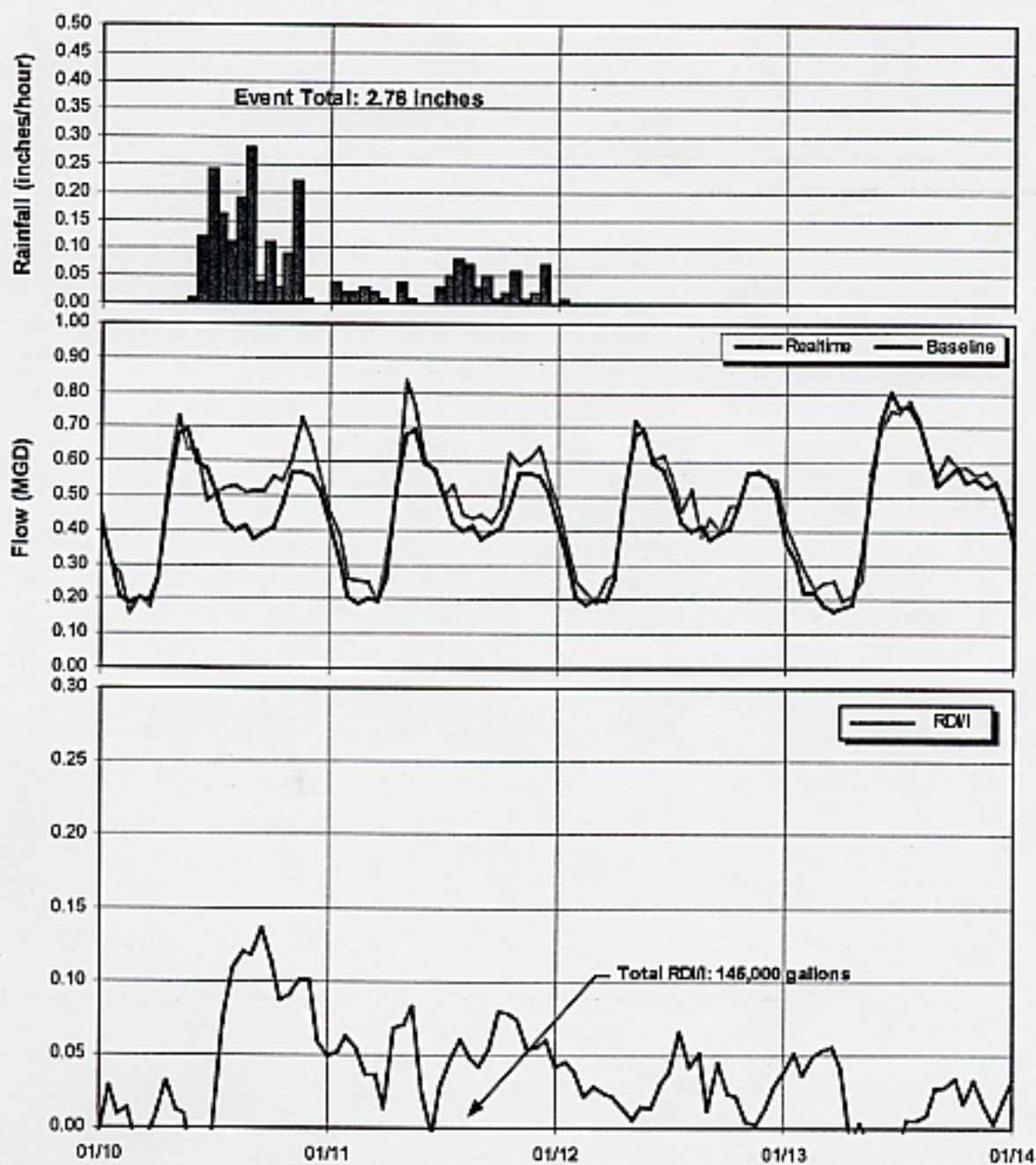
Site 8 Hydrograph, Event 1



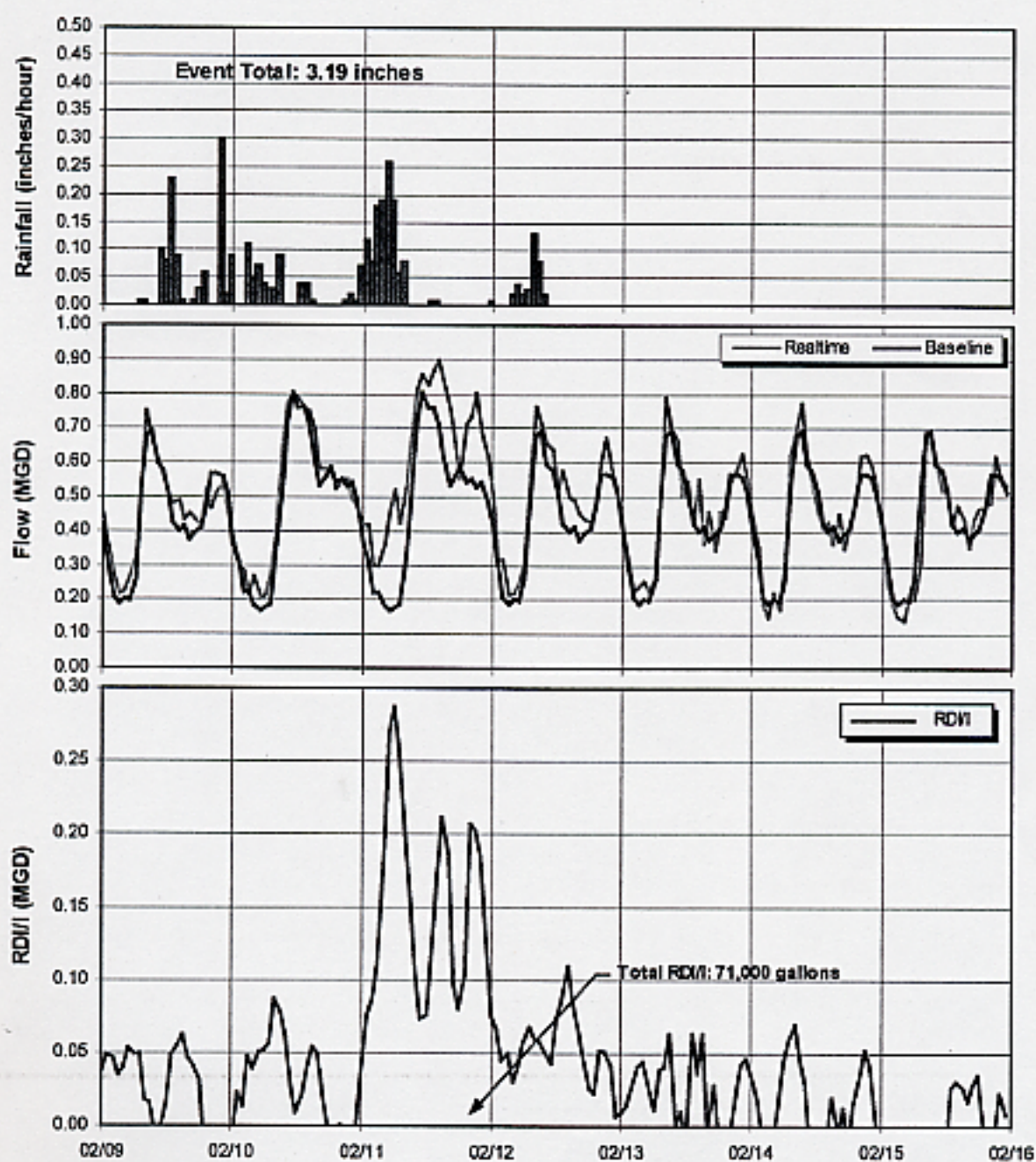
Site 8 Hydrograph, Event 1



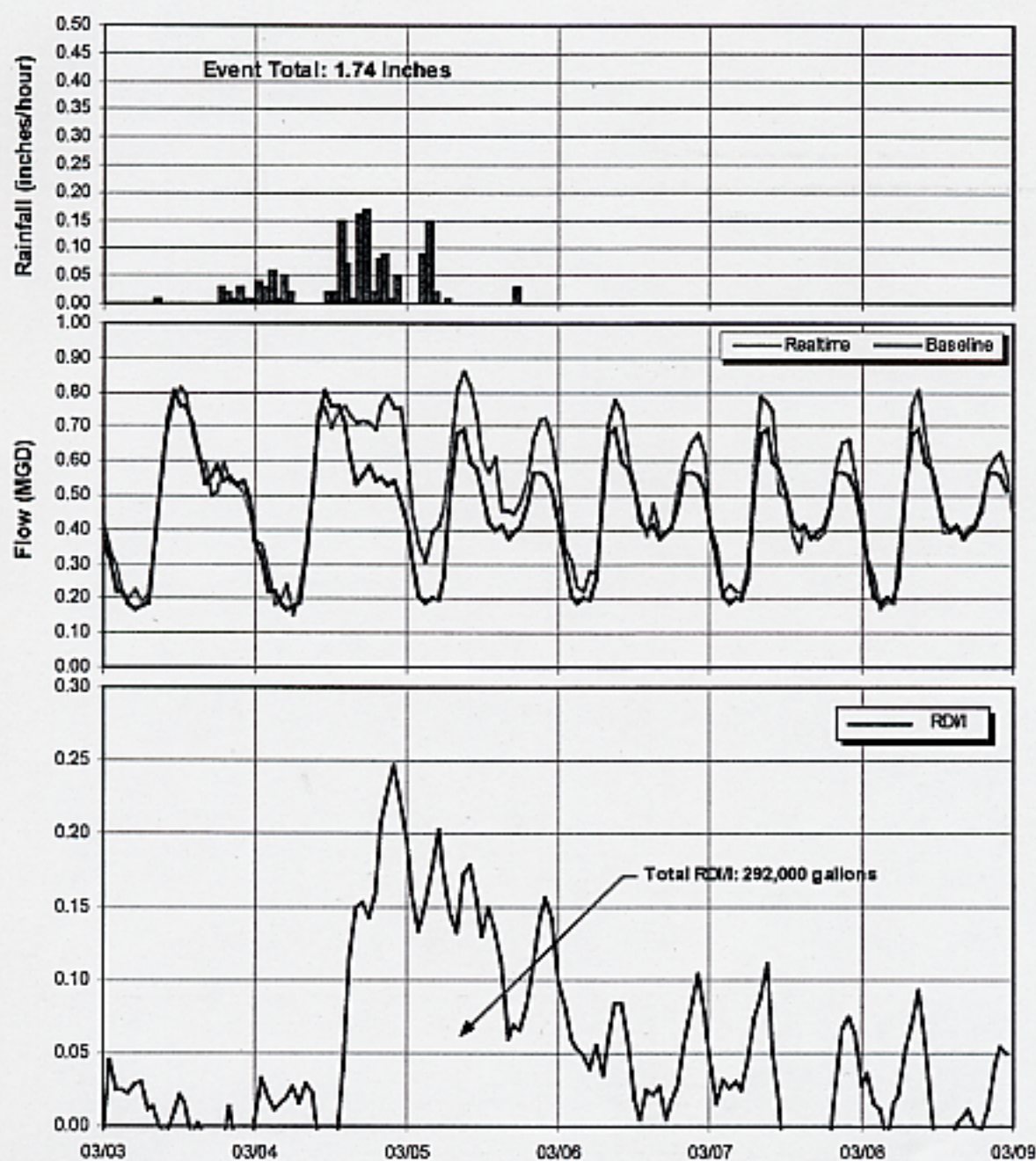
Site 8 Hydrograph, Event 5



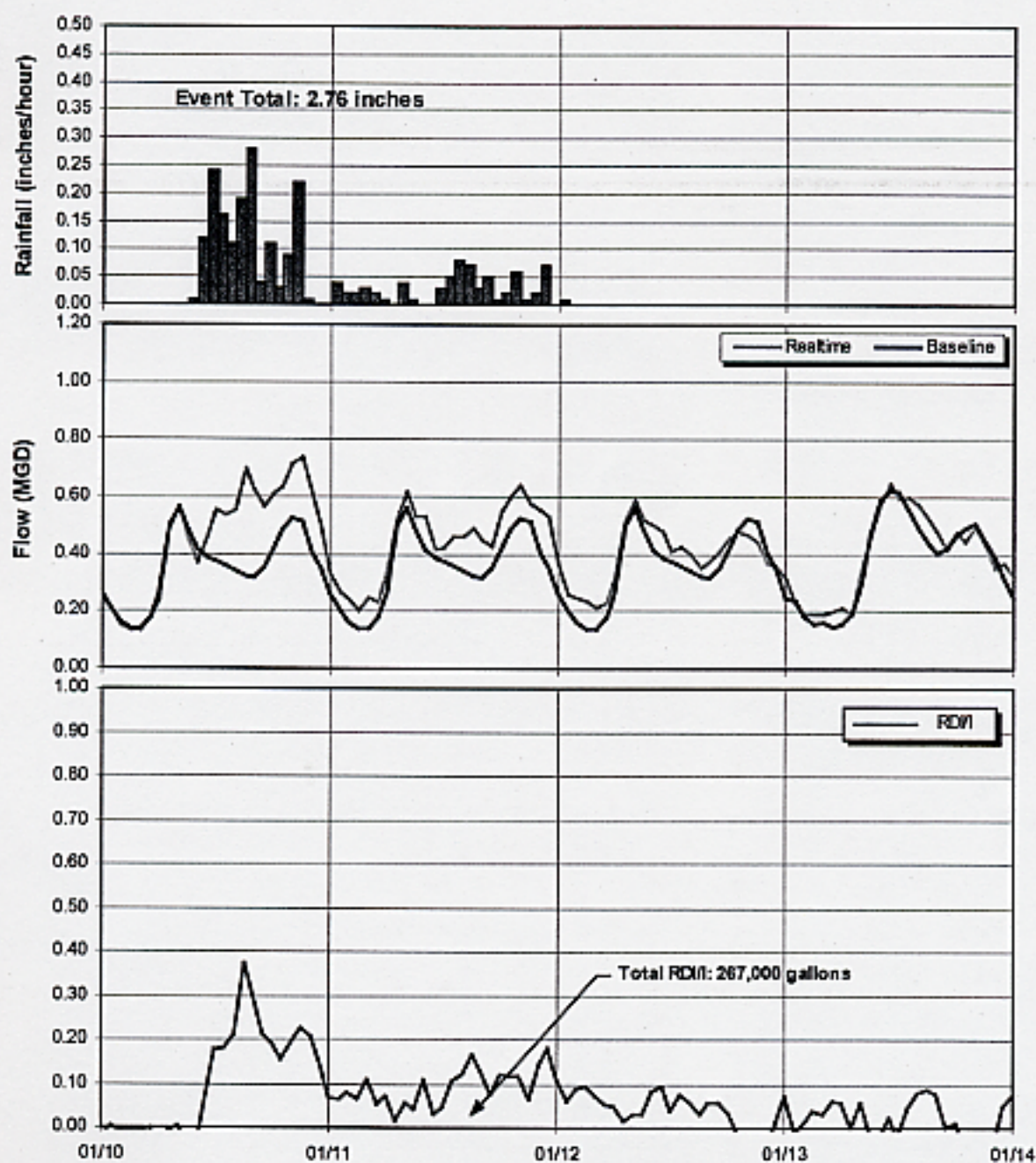
Site 11 Hydrograph, Event 1



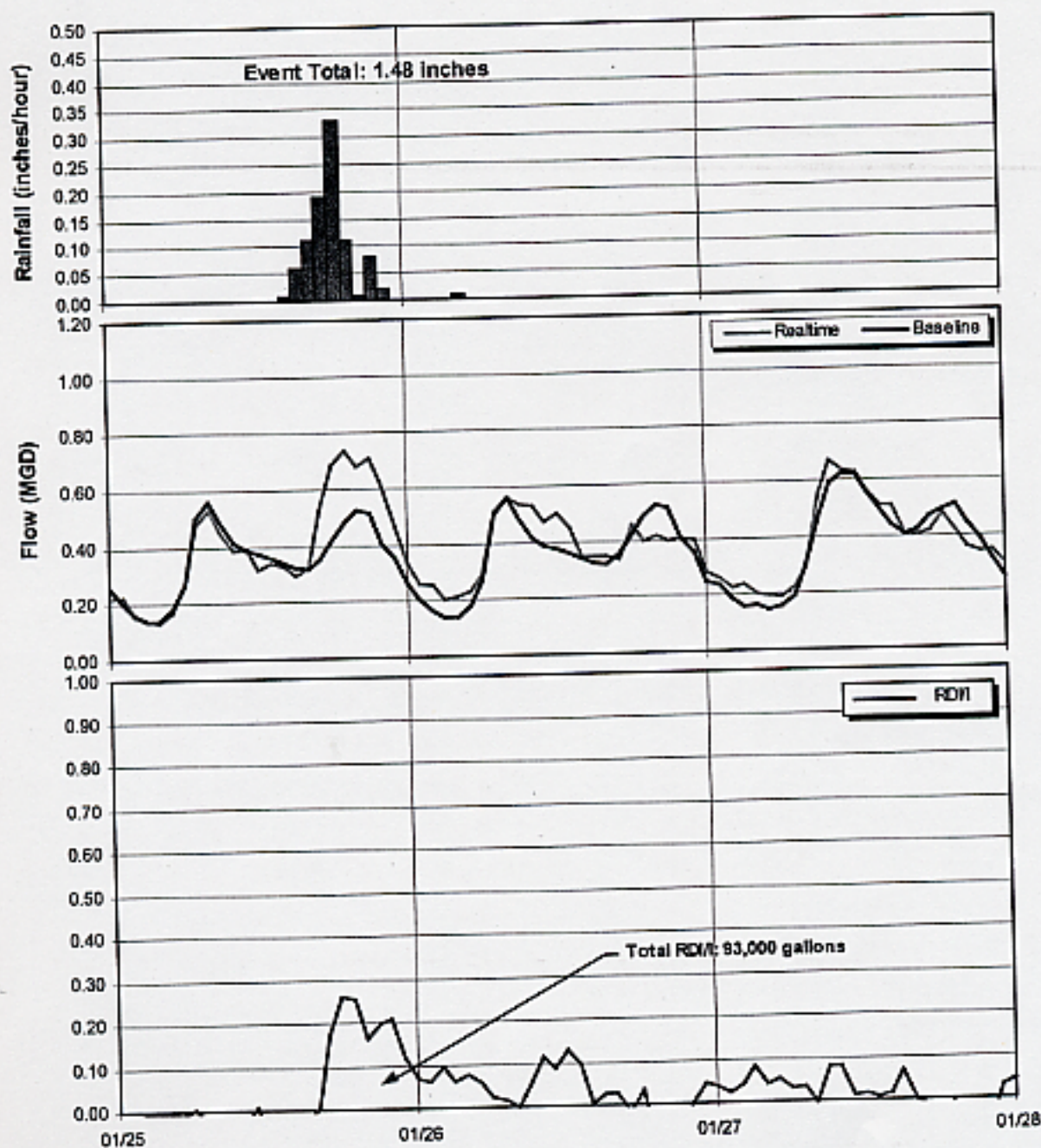
Site 11 Hydrograph, Event 3



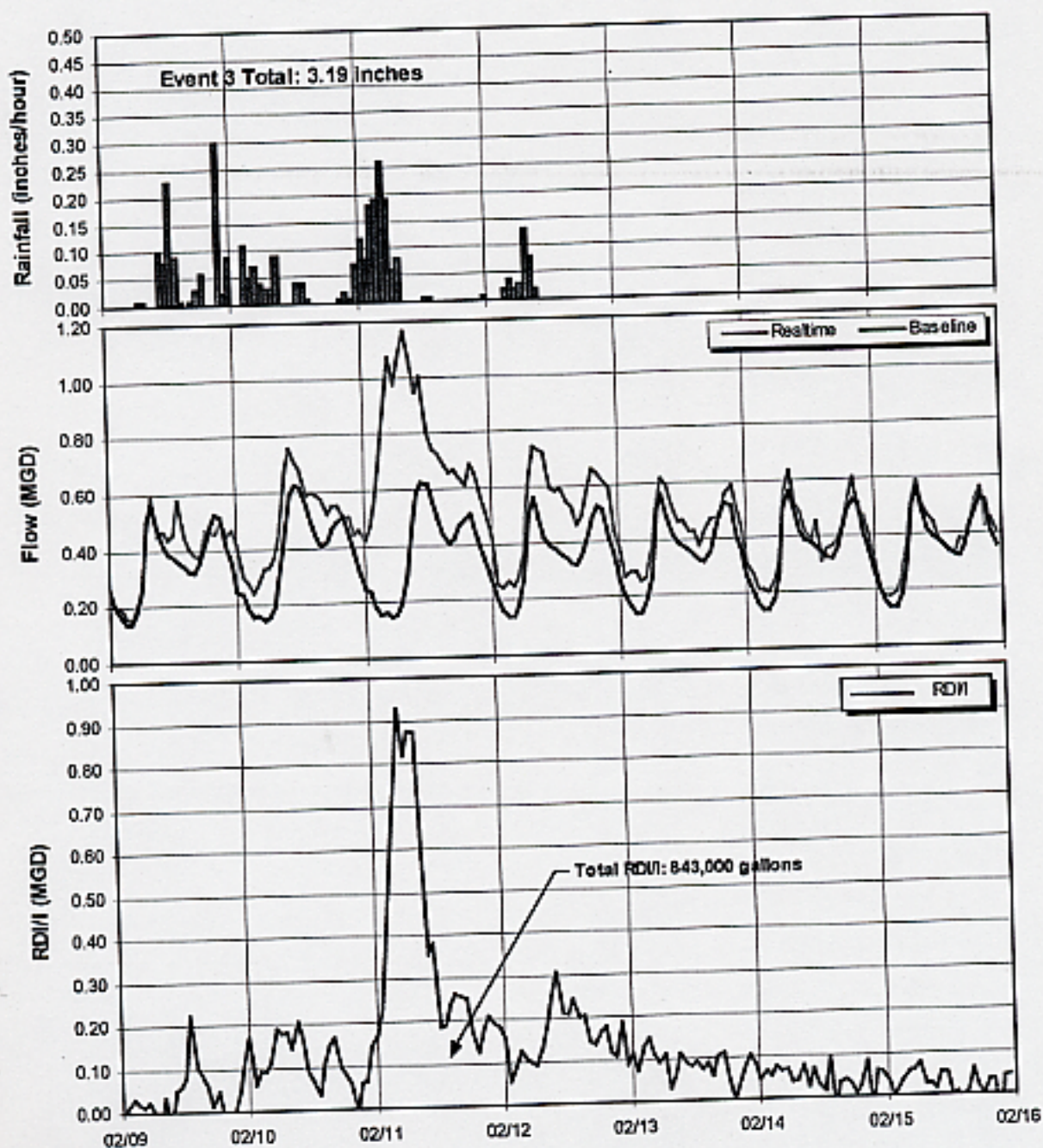
Site 11 Hydrograph, Event 5



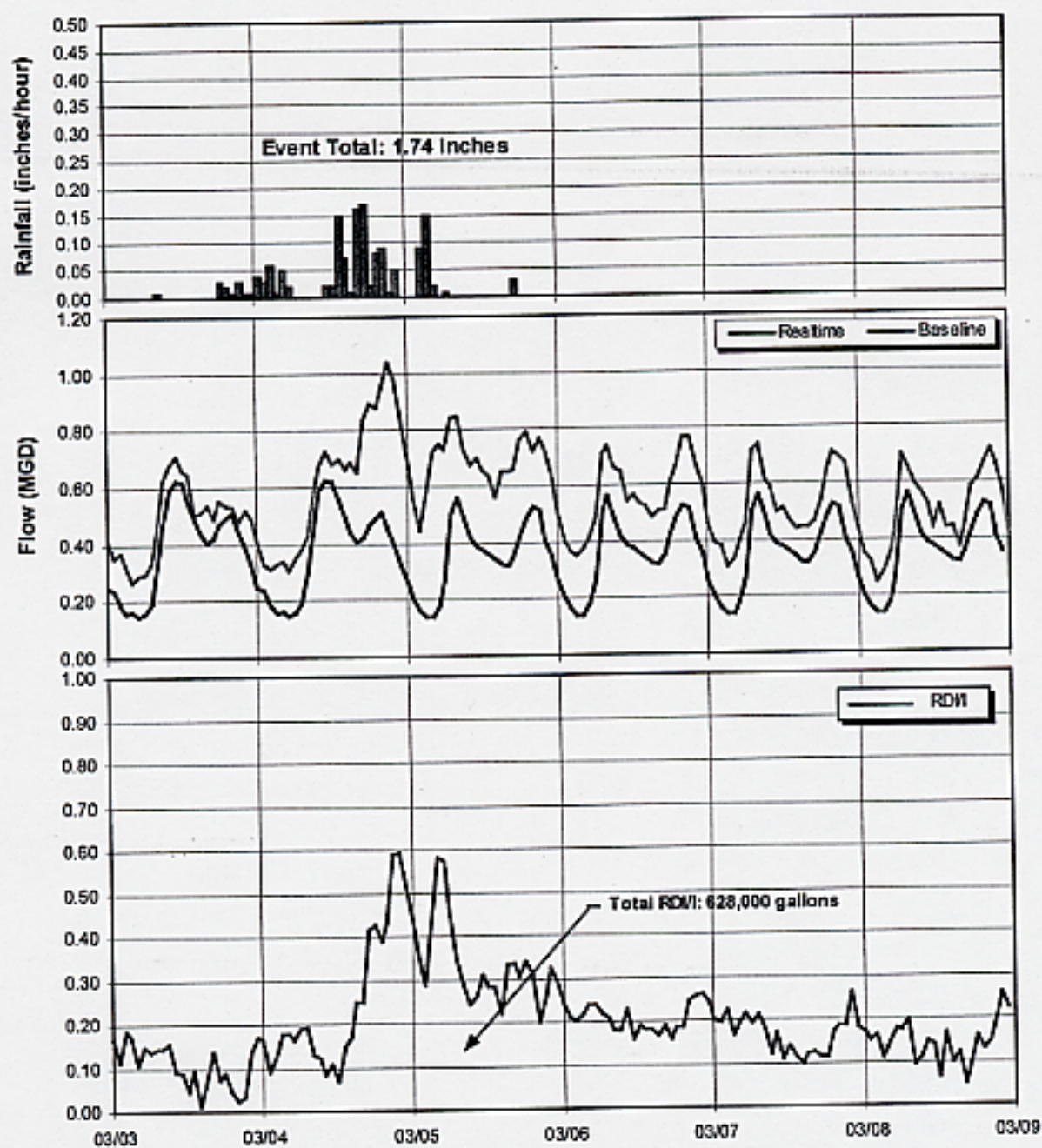
Site 13 Hydrograph, Event 1



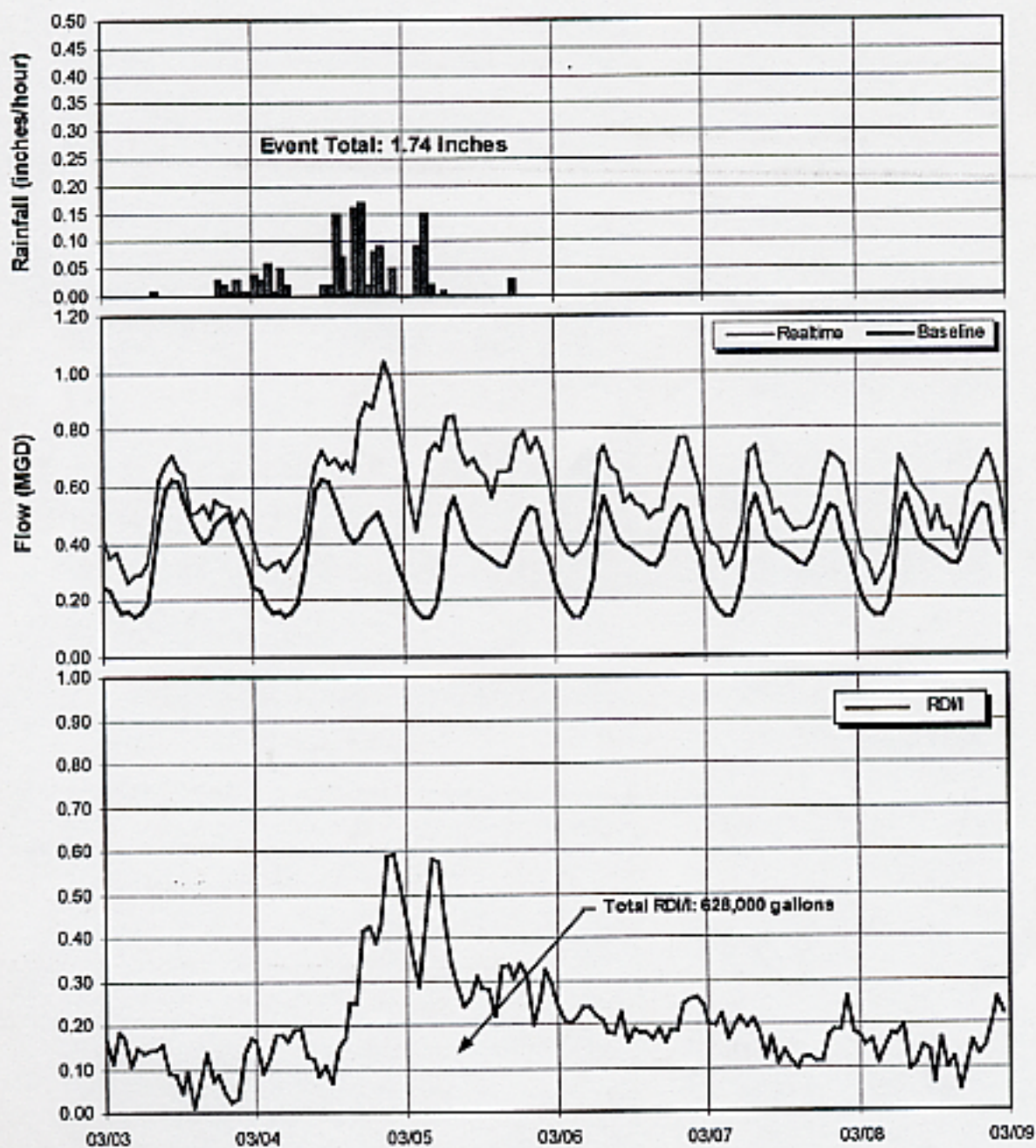
Site 13 Hydrograph, Event 3



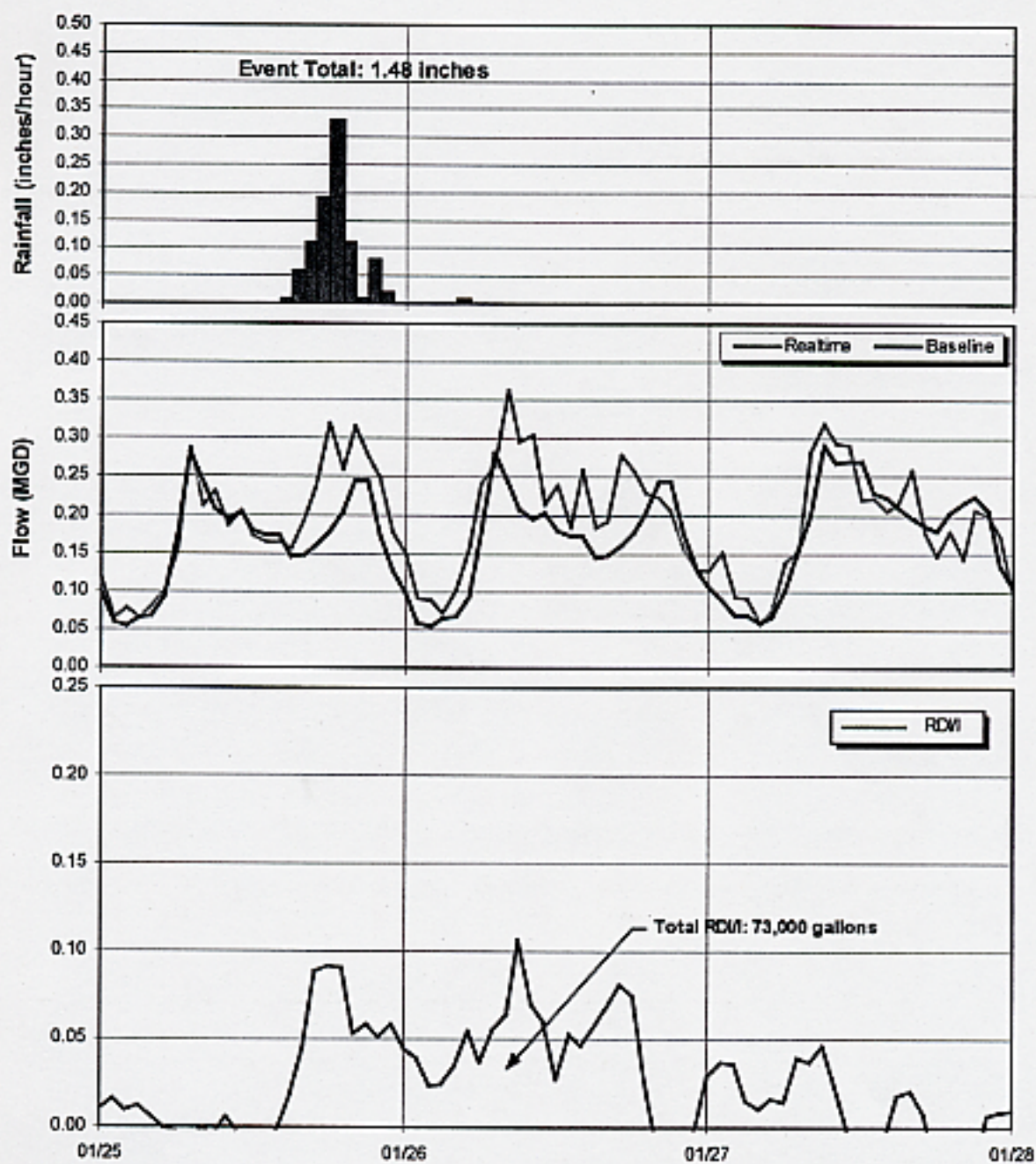
Site 13 Hydrograph, Event 4



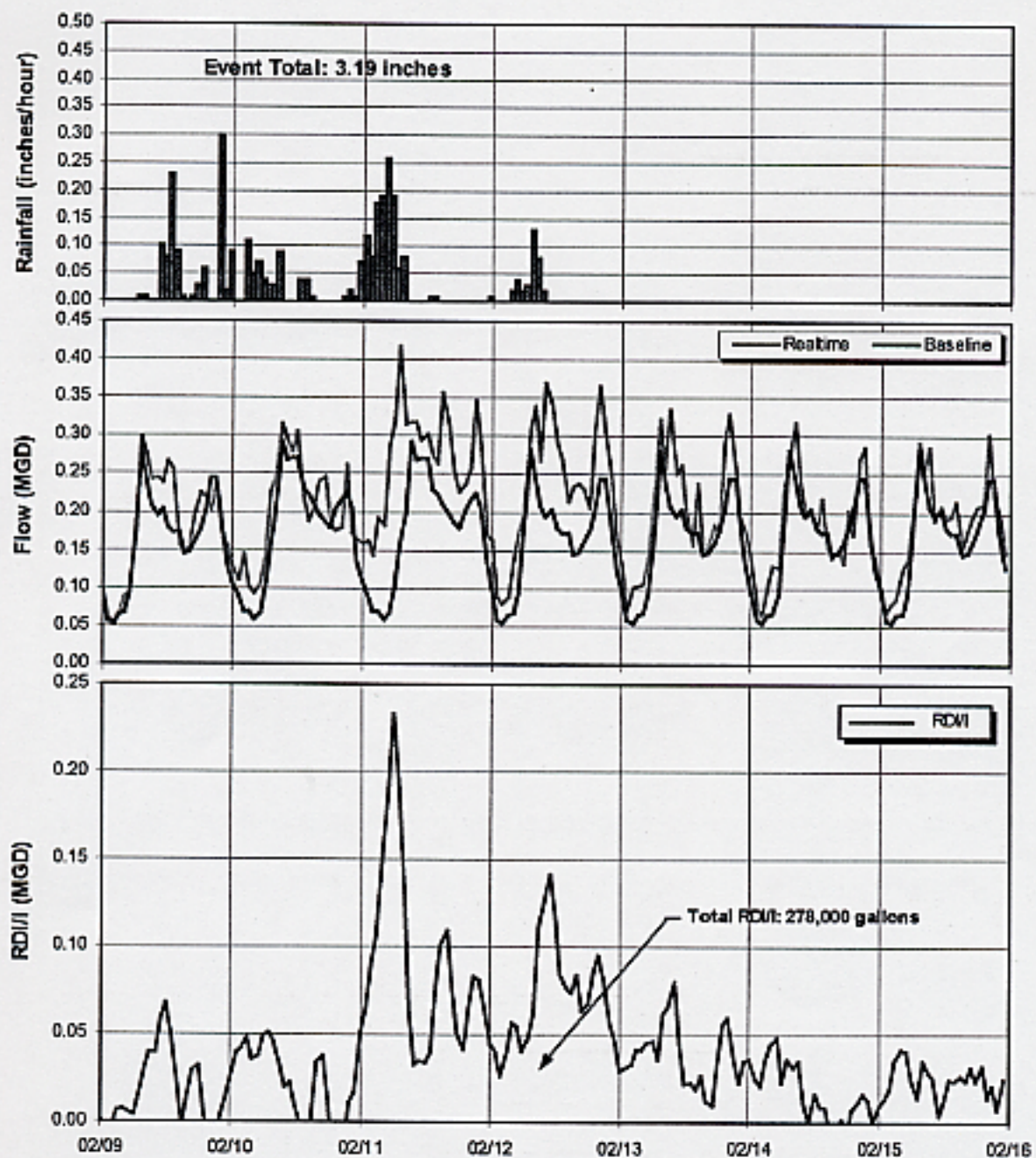
Site 13 Hydrograph, Event 5



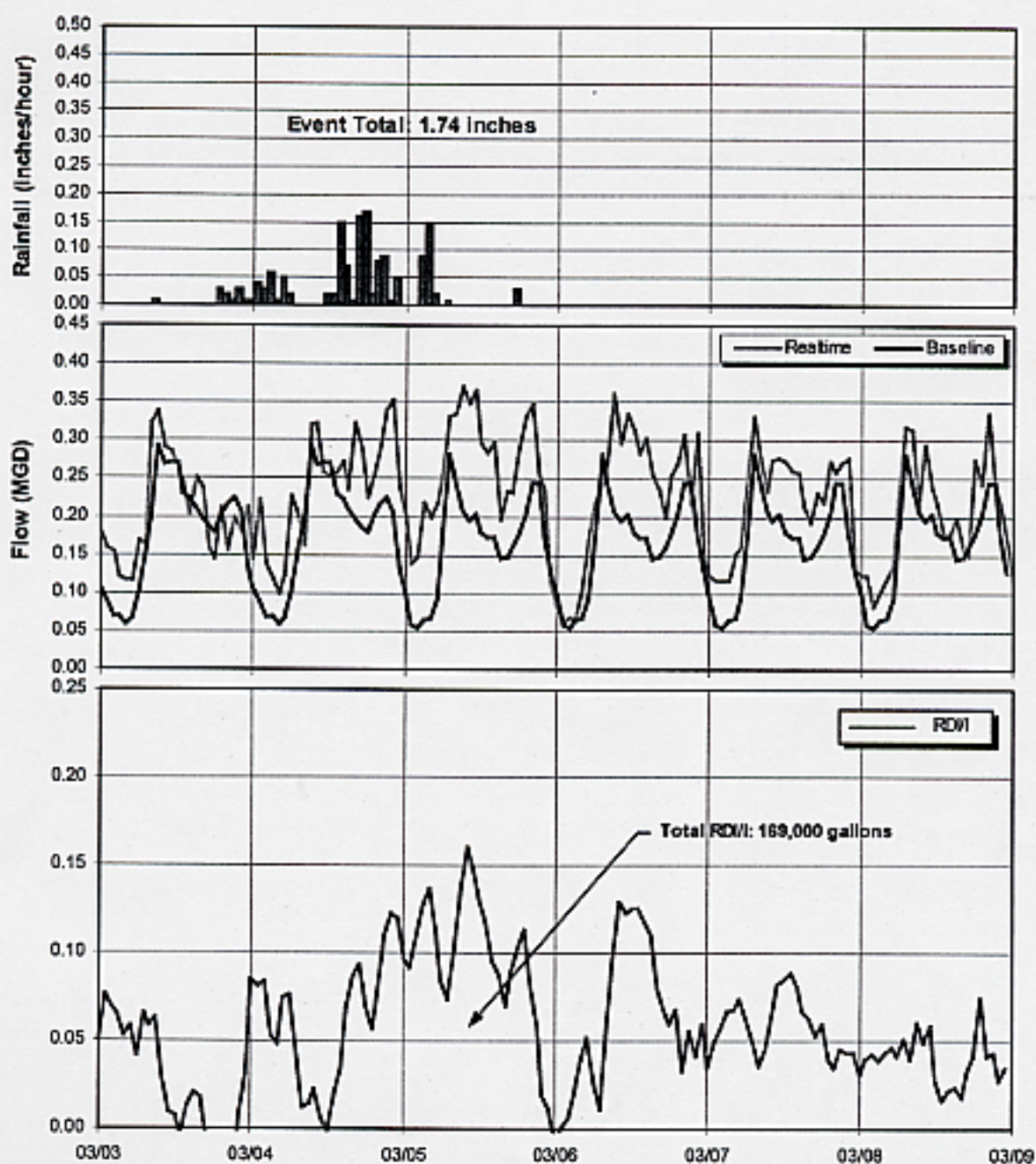
Site 13 Hydrograph, Event 5



Site 14 Hydrograph, Event 2



Site 14 Hydrograph, Event 3



Site 14 Hydrograph, Event 5